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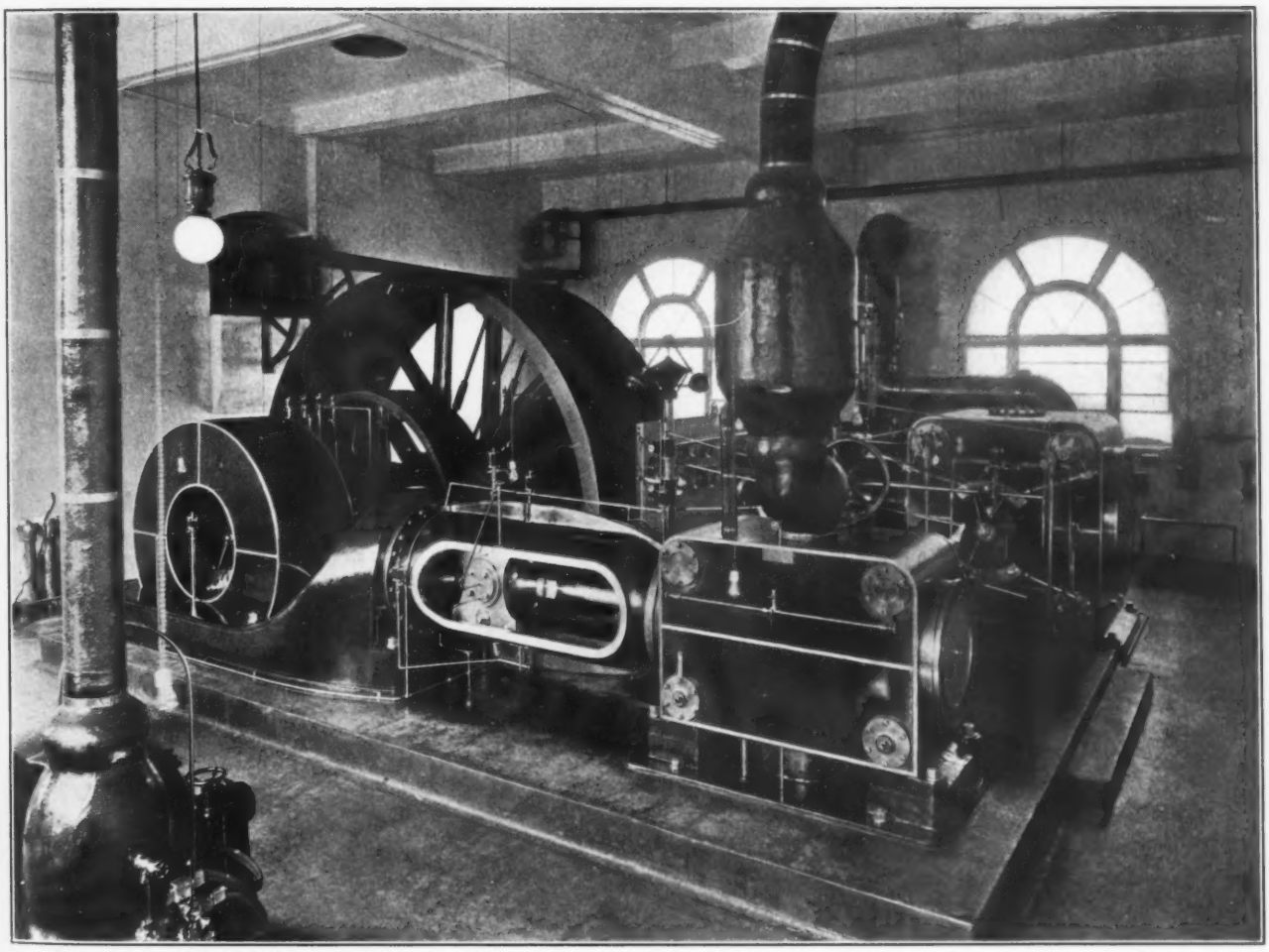
POWER AND THE ENGINEER

ISSUED WEEKLY BY THE HILL PUBLISHING COMPANY, 505 PEARL STREET, NEW YORK.

Vol. 29. Index to Advertisers and Classified Index Following Reading Matter No. 14.

Twin City CORLISS ENGINE



Large Cross Compound Twin City Corliss Engine, running one of the largest Flour Mills in Minneapolis. Fly wheel, 18 ft. diameter, grooved for 24 2-in. ropes. All machinery in the mill is run by belts from line shaft.

The only engine in this plant taking steam direct from boiler. Greatest possible economy in steam consumption.

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If we can't prove to you by that test that the DEAN removes scale more thoroughly, with greater ease, in less time, at less cost than any other cleaner on the market you may box it up and return it at our expense.

We know what the DEAN can do—so do 8000 steam users—but perhaps you don't and that is just why we want you to try it.

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Investigate the matter anyway. It won't cost you anything. You may have scale and don't know it—you may have inefficient scale fighters and don't know it. Wouldn't you like to be certain about it?

We send as many DEANS on trial to concerns who claim their boilers are "clean" as we do to those who know their boilers are dirty—and they "stick" because nine times out of ten the boilers are dirty—inspectors' reports, and engineers' opinions to the contrary notwithstanding.

Write for our booklet "From Water to Steam," and learn about Boiler Scale, anyway.

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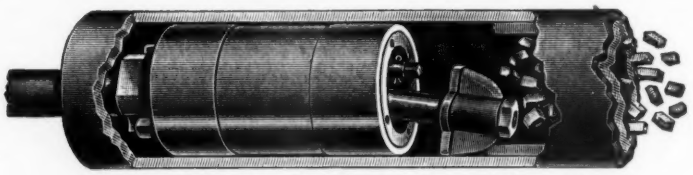
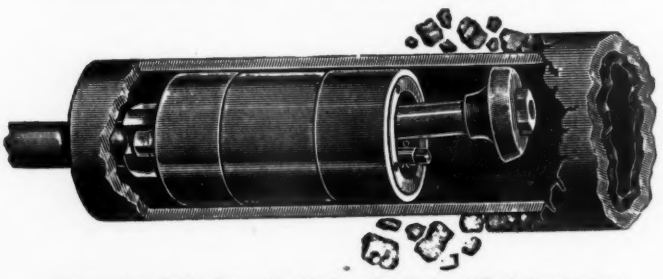


Removing Scale from the Tube of a Water Tube Boiler



Removing Scale from the Tube of a Return Tubular Boiler

8841a 2025

Have You Seen The FREE OFFER Of The KEYSTONE LUBRICATING COMPANY?

A LARGE CAN OF KEYSTONE GREASE, A FINE BRASS GREASE CUP AND AN ENGINEER'S COLLAPSIBLE LUNCH BOX sent express paid and absolutely free to engineers who want to know the wonderful value of

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Simply fill out and mail to us the attached coupon and the three articles will be started your way at once. We will be fully repaid if you will give Keystone Grease a fair test on your engines or auxiliaries.

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Name of Firm.....

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H. P. of Engine.....

On what bearing will sample be tested?

.....

Its width.....

R.P.M.....

Size of tap for cup.....

Oct. 6-08, Dept. B

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That's the great advantage of using

EBONITE
BLACK SHEET PACKING

Ebonite will easily out-hold any sheet packing you have ever used. It has the strength to—others haven't!

This extra holding strength in Ebonite means everything to you, especially if your high steam or superheated steam connections are giving you trouble. Just pack them with Ebonite—you won't have to worry any more. And remember that Ebonite is equally superior for all other joints.

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QUAKER CITY RUBBER CO.

PHILADELPHIA CHICAGO PITTSBURGH

VOLUMES have been written authoritatively on the excess cost of producing a given horse-power in boilers that are coated with incrustation. Scale one-thirty-second to one-sixteenth inch thick increases the fuel consumption ten to fifteen per cent., and greater scale thickness means greater loss of heat.

In these times of keen competition, when the greatest manufacturing economy must be exercised, the Engineer, Superintendent, Manager, Owner, are vitally interested in reducing these unnecessary operating expenses.

That the boiler water troubles are being successfully handled by the Dearborn Company, in 11,000 steam plants, keeping boilers clean, and preventing waters from pitting boilers and tubes, the work being done under a combination scientific laboratory and practical engineering guidance, should appeal to the discriminating operator desiring to better results.

Gallon samples of waters required for analysis, after which we will tell you how to remedy the troubles you experience, and the cost to do it right.

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Havana, Esquina Mercaderes y Cortina de Valdes
Indianapolis
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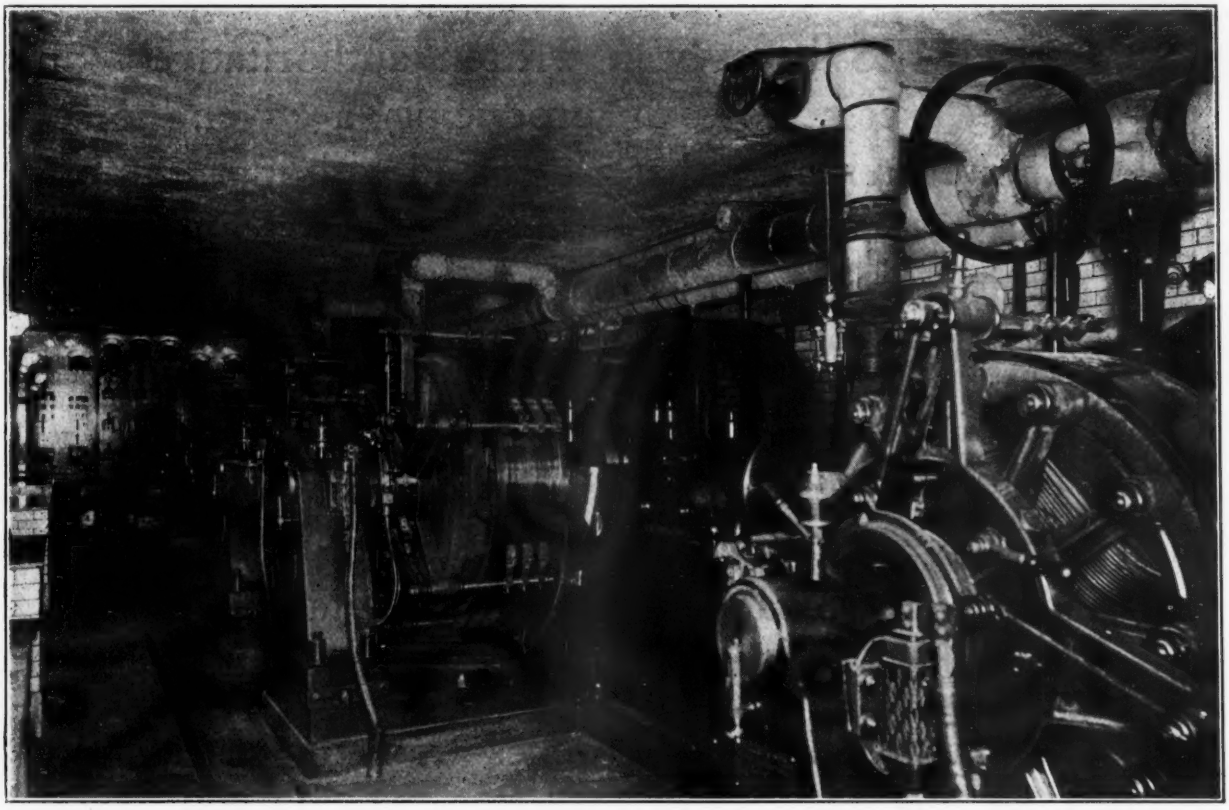

TO have to take down a line of piping to make a leaky flange tight is a job dreaded by every engineer, especially when it is the main steam main to a line of direct connected units as pictured above. This plant supplies the lights, etc., in a large office building. One of the flanges in the main line leaked and despite everything the engineer could do the leak remained, the covering became wet, discolored and the condensation dripped from the line causing the covering to fall off. (The ring in the picture shows where the flange leaked.) The engineer was persuaded to try SMOOTH-ON ELASTIC CEMENT, and then the next problem was how to apply it effectively without taking the piping down, and the following method was used which has given perfect results in hundreds of plants. The covering was removed around the flange and all valves were closed while full pressure was on the main, and while it was hot the SMOOTH-ON ELASTIC CEMENT was applied to the opening with a brush. The vacuum caused in the main drew in the cement and the heat metallized it. When all the cement had been drawn in that the opening would take, a stiff putty was made by mixing some of the SMOOTH-ON ELASTIC CEMENT with SMOOTH-ON IRON CEMENT No. 1, and this was forced into the opening by tamping it with a tool. The covering was replaced and no trouble has since been experienced from this flange.

Many of your leak troubles around the plant can be easily fixed with SMOOTH-ON. It is one of the handiest articles the engineer can have on hand—it is not a first aid but makes permanent repairs. Always be sure to get SMOOTH-ON products and beware of cheap substitutes.

Send for a copy of the SMOOTH-ON instruction book, it is well worth having.

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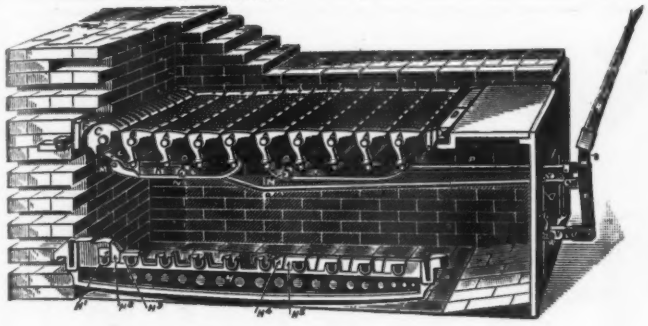
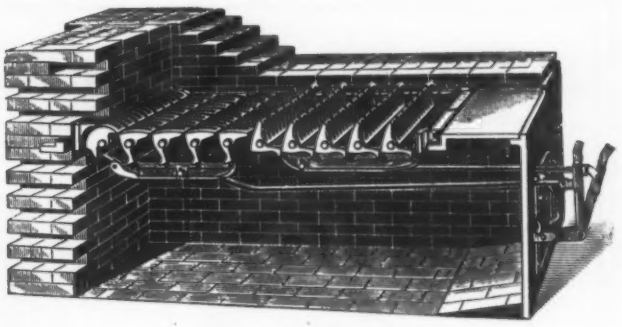


Normal Position of Grate



Divided Cut-Off

ECONOMY

In FUEL COST

ARGAND STEAM BLOWER

And FUEL USE

McClave Grates present a fire surface peculiarly suited to preventing waste of fine fuels. They also are fitted with shaking and dumping devices which enable the firemen to keep a perfectly clean, uniform fire over every inch of the grate without opening the fire door.

In combination with Argand Blowers these grates will secure actually better results from a small quantity of cheap fuel than any other grate can get with a large quantity of the most expensive fuel.

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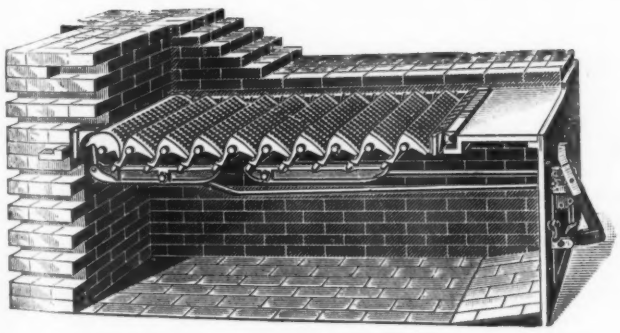
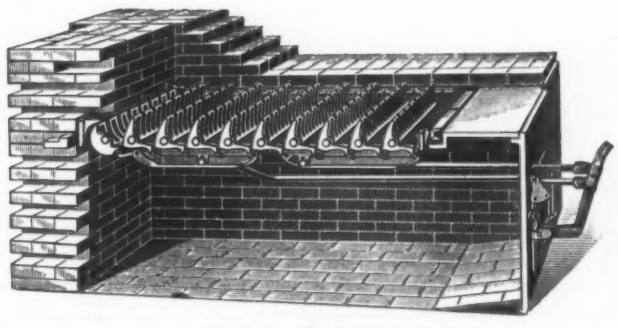


Shaking Movement



Whole Cut-Off Movement

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THE TRADE PENBERTHY MARK.

(Reg. U. S. Pat. off.)

AUTOMATIC INJECTOR

Always "Makes Good"

1st—It will work on higher pressure and handle hotter water.

2nd—It will lift further vertically on a greater range of pressure.

3rd—It delivers a maximum amount of water with a minimum amount of steam.

Try the PENBERTHY it never fails.

TRADE PENBERTHY MARK. **"XL-96"**

EJECTOR OR SYPHON

Has no equal in lifting or elevating liquids. Used Exclusively by the leading creameries, tanneries, breweries, brickyards, distilleries and dye houses in the country.

SPECIAL "XL-96" NON-ELEVATING EJECTOR

Heats liquids to a minimum; Lifts 28 feet; Uses less steam and delivers 33⅓% more liquid than any Ejector made. A trial will convince you.

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The new "Engineer & Fireman" (80 page magazine) will be sent to any engineer who will send his name and address.

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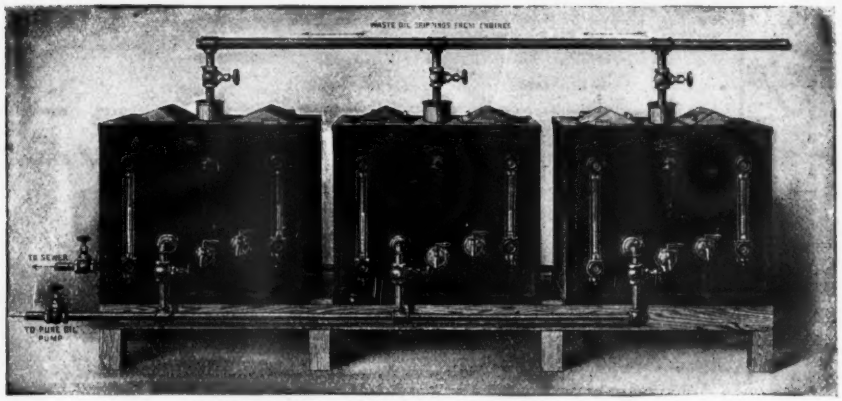
Burt Unit Oil Filters



Three Units connected and operated as one filter.

So constructed that they can be operated singly or in batteries as large as may become necessary. They remove oil and save from 50% to 90%. Each unit will deliver clean and pure 200 to 250 gallons every 24 hours. The Philadelphia Rapid Transit Co. uses 26 (fifth order) Units. Calumet & Hecla Copper Co., 7 (repeat orders). U. S. Steel Corp , 15 (ninth order).

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Largest Manufacturers of Oil Filters in the World.

The Burt Exhaust Heads

effect complete separation of oil and water from exhaust steam, keeping walls and roofs dry and free from decay.

This is the most satisfactory device known for muffling the exhaust pipe.

The Pullman Co., Chicago, recently ordered their 33rd Burt Exhaust Head.

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Largest Manufacturers of Oil Filters in the World.

Electric Drive for Metal Working Shops

The Essential Factors and Advantages which Make for Adaptability, Reliability and Economy with This Form of Transmission

BY NORMAN G. MEADE

The adaptability, reliability and economy of electric drive are three factors that apply to industries of all kinds. There are many specific advantages, however, which are gained in each particular line of work. In general, for machine shops and metal-working establishments, electric motors are adapted to driving any kind of machine used, and will perform the work with less expense than any other power. Some of the reasons for this increased economy are: That with individual motor-driven machines, belting and shafting are eliminated and from 25 to 60 per cent. of the power lost in overcoming friction is saved. Further, the operating cost is confined to the current actually consumed in performing useful work. Another consideration is that with electric drive one machine is independent of all others and can be started or stopped at will, and when stopped its expense ceases. This independent operation permits the machines to be placed in

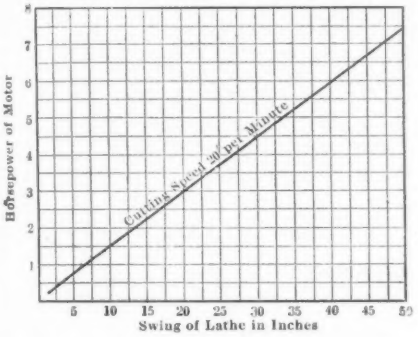


FIG. 3. HORSEPOWER CURVE FOR LATHES

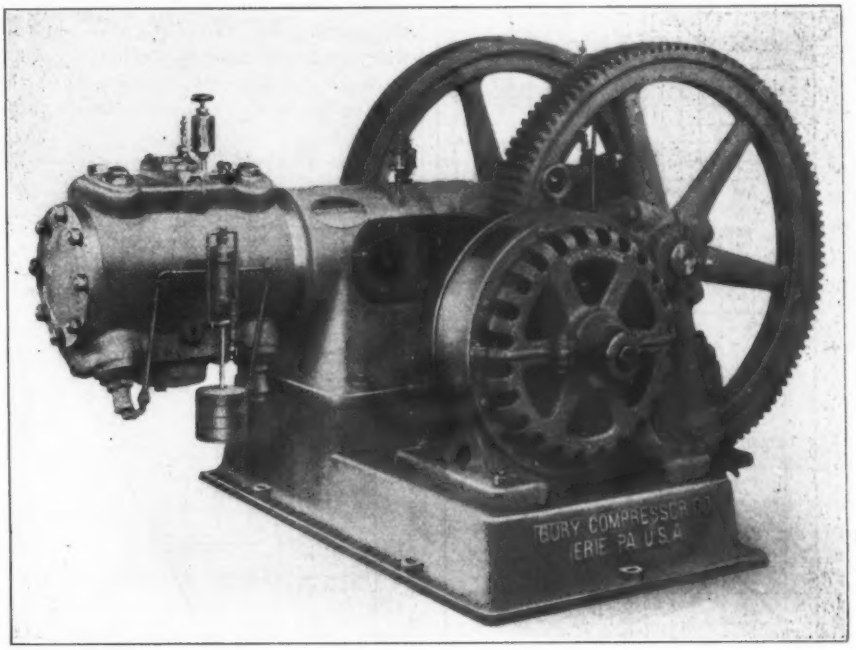


FIG. 1. AIR COMPRESSOR DRIVEN BY INDUCTION MOTOR

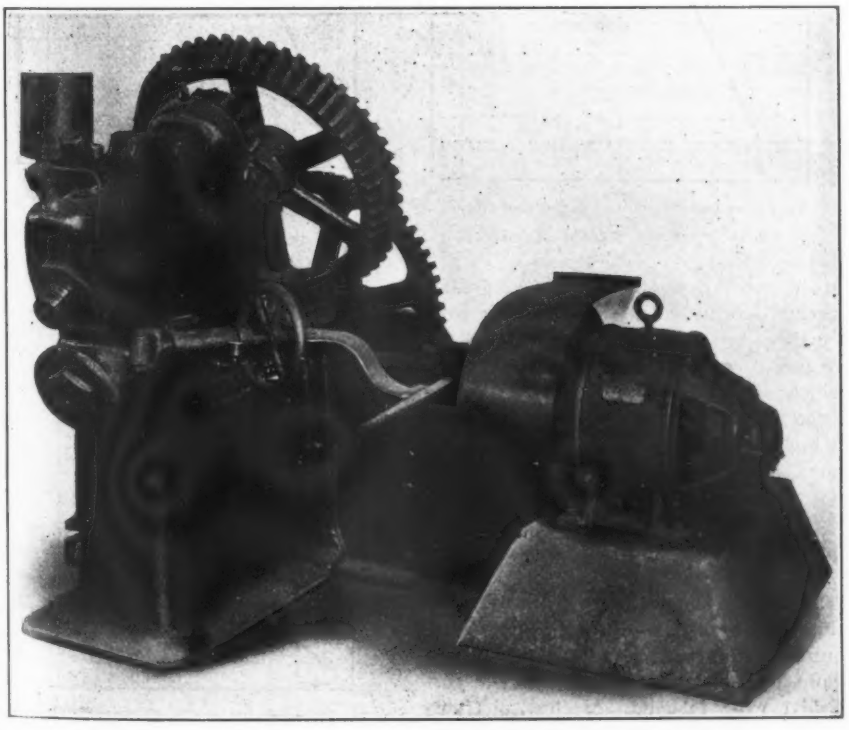


FIG. 2. BEVEL SHEARS DRIVEN BY A DIRECT-CURRENT MOTOR

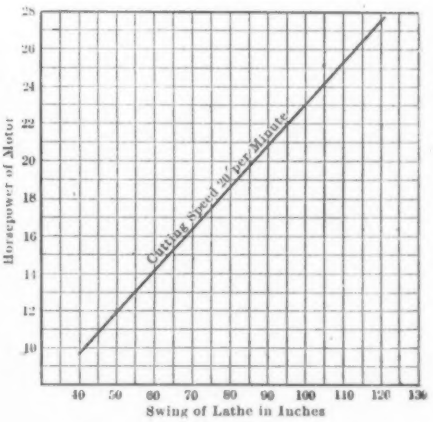

Horsepower of Motor
Cutting Speed 30' per Minute
10 12 14 16 18 20 22 24 26 28
40 50 60 70 80 90 100 110 120 130
Swing of Lathe in Inches

FIG. 4. HEAVY FORGE LATHES

the positions logical for sequence of operation in the manufacturing process.

Uniform Speed Increases Production

Increased production of the machines is obtained due to the uniform speed of motor driving and the ease with which speed regulation over a wide range is effected, for to operate machines at their highest producing capacity, suitable speeds must be available, and these speeds must be readily obtained. With mechanical transmission of power, the shifting of belts to obtain variations of speed is slow, and it is not possible to obtain fine increments of variation with the usual mechanical speed changers.

It is thoroughly recognized that anything which adds to the efficiency of employees increases the economy of operation. This increased efficiency is aided by the elimination of belts and shafting, whereby better lighting, both natural and artificial, is obtained as well as better ventilation, which adds to the comfort of the operatives and creates a greater incentive to increased effort on their part. Further, economy is gained by the increased output per unit of floor space, which is of considerable importance in locations where the value of real estate is high. Additions to the plant are facilitated, as motors to provide for increased power demands can be easily installed without regard to the location of the buildings.

In machine shops, rush repair jobs are frequent and require a great deal of overtime and Sunday work, when power requirements are small, as but sufficient machinery is operated to complete the particular work in hand. Mechanical transmission of power under such circumstances is wasteful in the extreme, owing

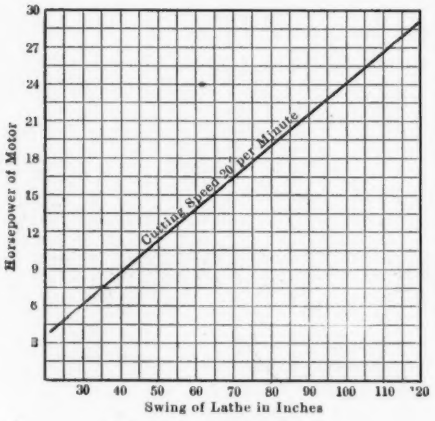


FIG. 5. BORING MILLS

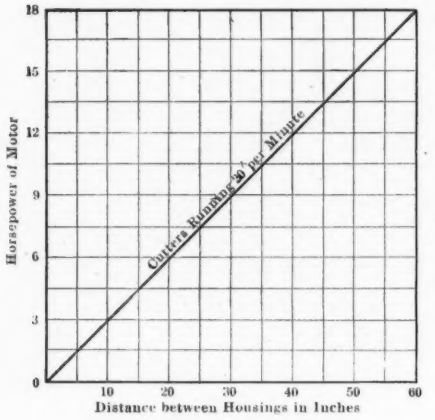


FIG. 6. MILLING MACHINE

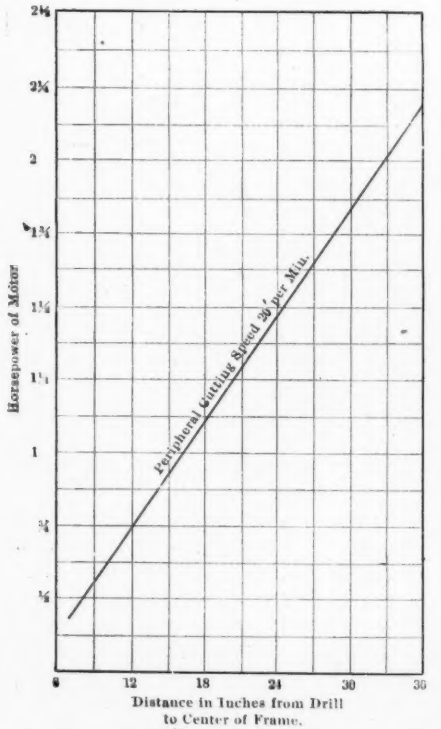


FIG. 7. DRILL PRESSES

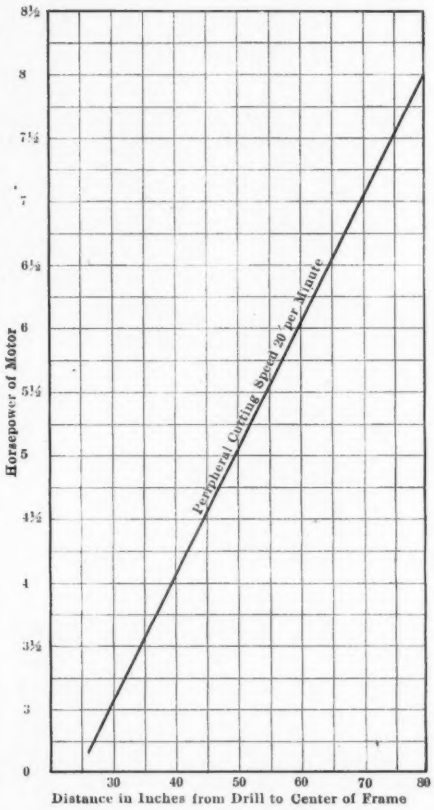


FIG. 8. HEAVY RADIAL DRILLS

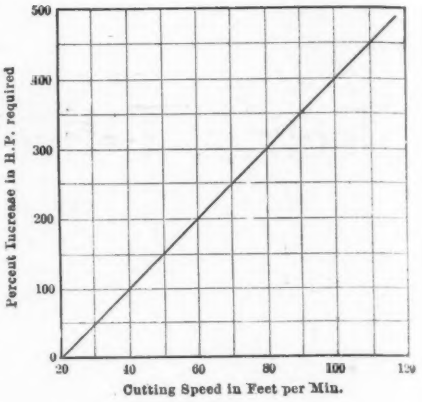


FIG. 9. HORSEPOWER INCREASE FOR HIGH CUTTING SPEEDS

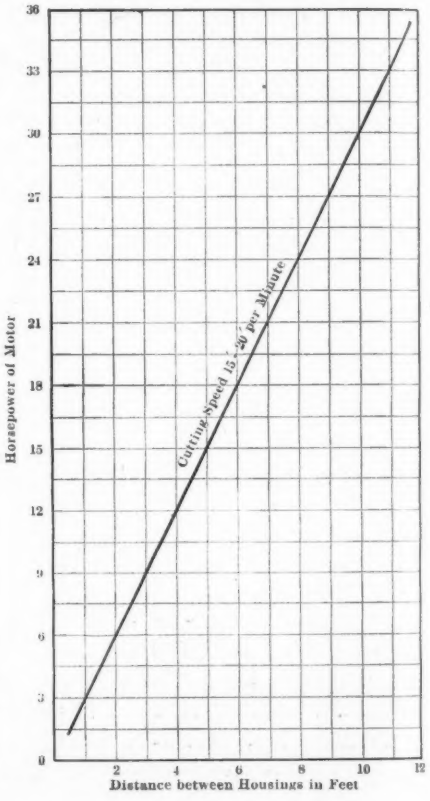


FIG. 10. POWER REQUIREMENTS OF PLANERS

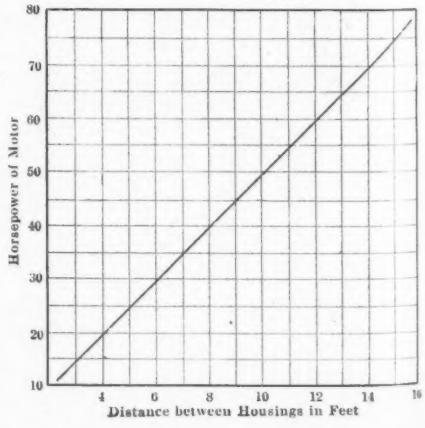


FIG. 11. POWER FOR HEAVY FORGE PLANERS

to the surplus power required in overcoming the friction of the shafting and belting.

Portable Machines of Great Convenience

Another feature in favor of electric drive in the machine shop is the use of portable motor-driven machines, which can be readily adapted to a large number of operations and moved about and applied to the work, thereby saving much time and expense in moving heavy castings. The portable machines in most extensive use are drills, grinders, slotters and small boring mills with revolving tools suitable for boring small diameters in large castings.

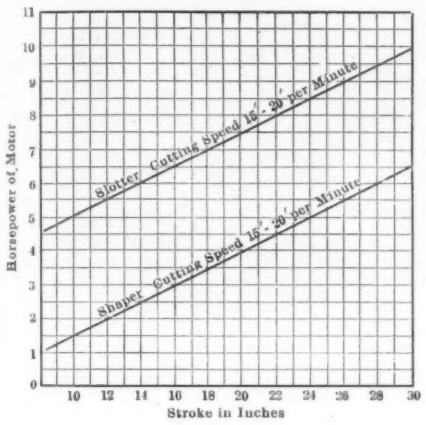


FIG. 12. POWER REQUIRED BY SLOTTERS AND SHAPERS

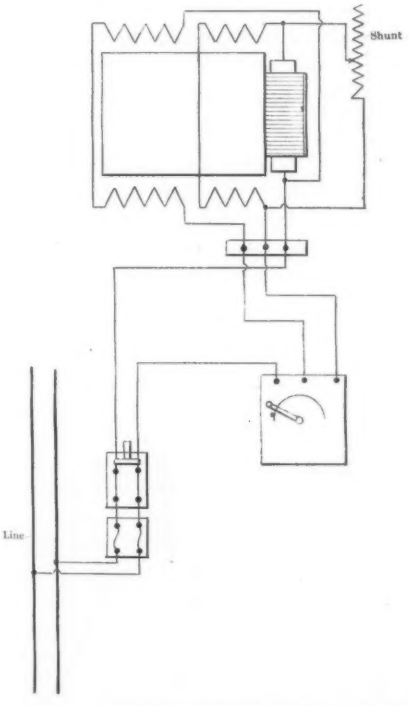


FIG. 13. COMPOUND-WOUND MOTOR WITH SHUNT

For handling small work the electric hoist, supported by a jib similar to that used for the ordinary jib crane, has proved a great labor saver. These hoists are controlled by pendents which are within easy reach of the floor. The pieces of work can be quickly lifted, turned over or moved with but very little exertion on the part of the operative. Electric traveling cranes are so largely used and their advantages so well known that they need no further discussion.

FIG. 14. AUXILIARY-POLE VARIABLE-SPEED MOTOR

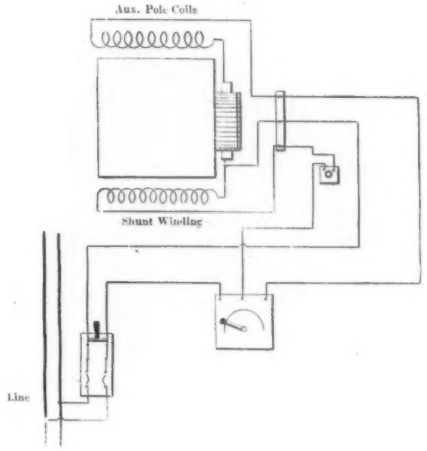


FIG. 15. AUXILIARY-POLE VARIABLE-SPEED MOTOR

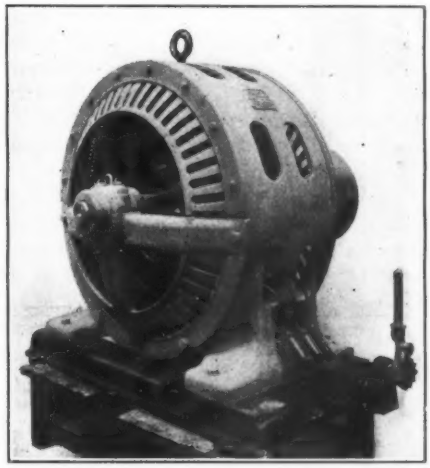


FIG. 16. STANDARD INDUCTION MOTOR

Small electric locomotives in large shops are invaluable for hauling material from one department to another, and are a means of considerable saving in the expense of labor.

Air Compressors Should be Motor Driven

There are many auxiliary appliances used in machine shops and metal-working establishments that are very well adapted to motor drive, and chief of these is the air compressor, which is in general use for the operation of pneumatic hammers and other appliances. Steam-driven compressors give poor economy, from the fact that when the pressure in the air cylinders is approaching maximum, the steam in the steam cylinders is working expansively and the pressure rapidly falling. When the compressors are motor driven, the fluctuating power demands are instantly met. Fig. 1 illustrates a Berry compressor driven by a Westinghouse induction motor. Aside from air compressors there are fans, pumps and numerous other devices well adapted to motor drive.

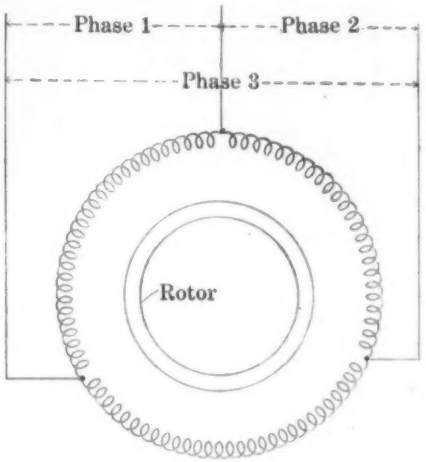


FIG. 17. THREE-PHASE INDUCTION MOTOR

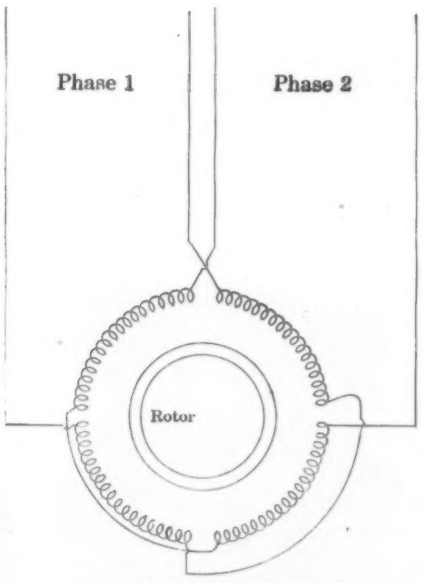


FIG. 18. TWO-PHASE MOTOR

Fig. 2 illustrates a motor-driven application.

Shunt Motor for Rotary Work and Compound for Reciprocating

In general, motors used for lathes, boring mills, milling machines, drill presses and machines of similar character having

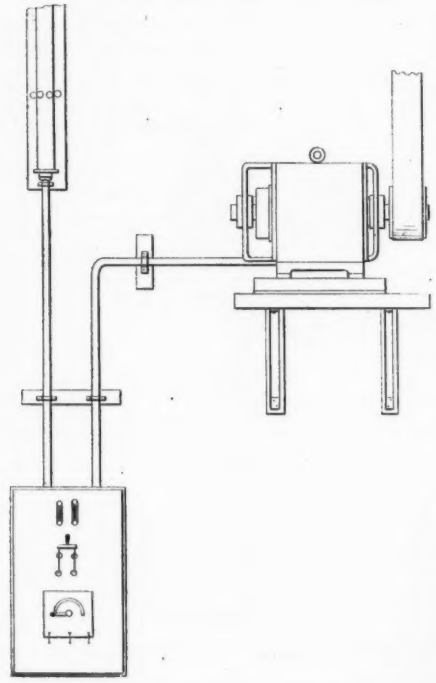


FIG. 19. GROUP DRIVING FROM BRACKET

a rotary motion of work or cutter, should be shunt-wound variable-speed, with good inherent speed regulation.

Machines having a reciprocating motion are, from their nature, less productive than machines having a rotary motion of either work or cutter. For this reason

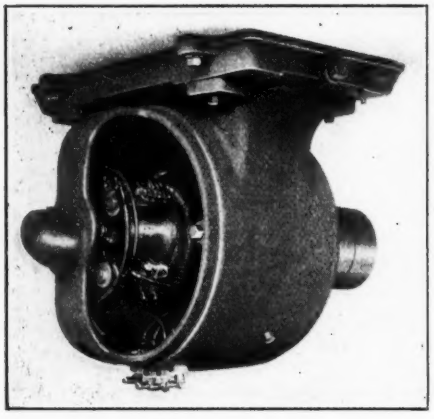


FIG. 20. MOTOR ADAPTED TO CEILING SUSPENSION

it is important that machines having a reciprocating motion be run at the limit of their capacity. This, of course, requires a motor capable of some speed regulation, but a compound-wound machine should be invariably used. The compound-wound motor, when the torque required is considerably in excess of the normal, will hold the inrush of current within reasonable limits, which may be further improved by the use of a flywheel.

The curves from Figs. 3 to 8, inclusive, are for machines having a rotary motion and using one cutting tool of water-hardened steel. If high-speed tools are used, running at a higher cutting speed than those given, the increase in horsepower should be approximately proportional to the increase in speed. This is shown by the curve in Fig. 9. Figs. 10 and 11 are curves showing the power requirements of planers having a ratio of cutting to return speeds of approximately 1 to 3, and cover planers with two tools in operation. If more than two tools are used, or if the ratio between the forward and return speeds is more than 1 to 3, the horsepower should be increased. The power requirements of slotters and shapers is shown in the curve of Fig. 12.

For group driving the constant-speed, direct-current, shunt-wound motor or the constant-speed induction motor should be

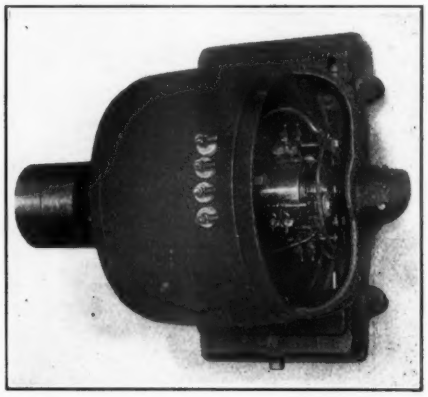


FIG. 21. DIRECT-CURRENT MOTOR MOUNTED ON WALL

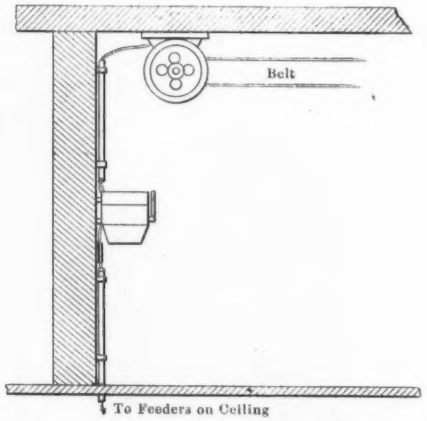


FIG. 22. WIRING FOR INDUCTION MOTOR ON CEILING

used, the inherent speed-regulating characteristics of both types being similar.

Compound-wound Motors

There are several considerations to be thought of in the operation of a compound-wound motor. It will vary in speed with the variation in load more than a shunt-wound motor, but will not vary so much as a series-wound motor. The relative proportions of the series and shunt windings determine the exact operating characteristics. Fig. 13 shows the connections of a compound-wound motor using a shunt, which consists of a resistance strip which takes a portion of the

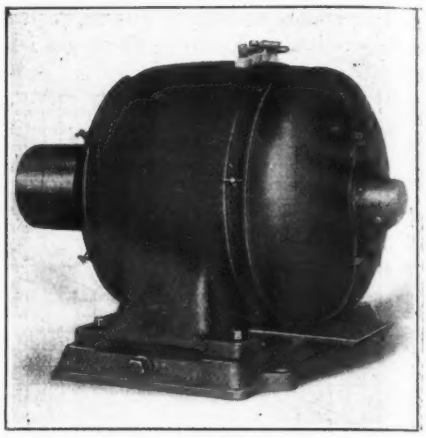


FIG. 23. MOTOR ENTIRELY INCLOSED

current that would naturally flow through the series winding. The shunt may be adjusted to vary the amount of resistance. To illustrate its use, assume that a fan is being operated by the motor and that the blast is shut off. If the damper is suddenly opened, the load increases suddenly, and the series winding enables the motor to meet the increased torque demand and maintains a field for sparkless commutation. The variations in the load are not frequent nor very severe, so that the compounding action is not needed to so great an extent as would be the case if the motor were operating a planer or

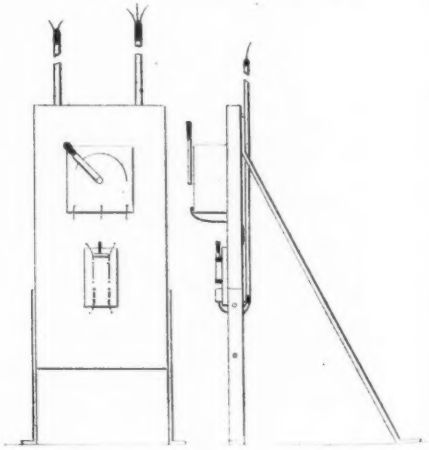


FIG. 24. PORTABLE MOUNTING FOR MOTOR-CONTROLLING APPARATUS

shaper where the reversals are sudden and severe. It is apparent, therefore, that for operating a fan the full strength of the series winding is not needed, so the shunt is all connected in circuit. If the motor is transferred to a planer, owing to the severe nature of the work, the resistance of the shunt would be reduced, as

shown in the figure, the amount of resistance needed to be determined by trial.

Auxiliary-pole Motor

The auxiliary-pole or interpole motor, illustrated in Fig. 14, has become quite generally adopted for the operation of machine tools requiring a wide range of speed. It is essentially the same in construction as the constant-speed shunt-wound motor, with the exception of an extra set of poles fastened to the frame between the main poles and connected in series with the armature. These auxiliary poles maintain a field for sparkless commutation regardless of the field weakening for speed regulation and of the direction of rotation of the armature. Fig. 15 shows the connections. The field rheostat for regulating the speed of the motor by introducing field resistance in circuit with the shunt winding is shown near the motor. It is common practice to use a controller which regulates both the starting and stopping and the speed regulation, thus preventing the starting of the motor with weakened field.

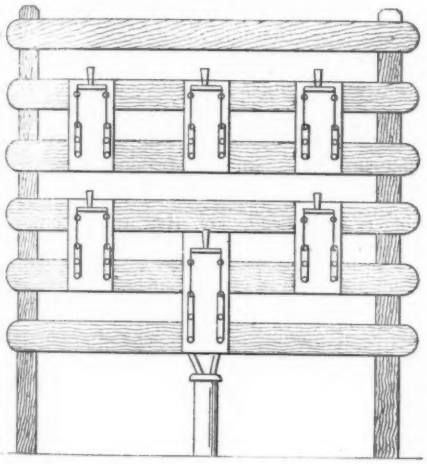


FIG. 25. SIMPLE FEEDER SWITCHBOARD

Induction Motors

Fig. 16 illustrates a standard type of induction motor, and Figs. 17 and 18 the connections of a three- and two-phase winding for this type of machine. For group driving the motor should preferably be located on a bracket, as shown in Fig. 19, or suspended from the ceiling or mounted on the wall, as shown in Figs. 20 and 21, respectively. Fig. 22 illustrates a method of wiring an induction motor suspended from the ceiling.

The choice of an open, semi-inclosed or entirely inclosed motor should be decided by the surrounding conditions. When the motor is located in a clean, dry place and not subjected to the danger of foreign material falling into it, the open motor is preferable owing to good ventilation. If the atmosphere surrounding a motor is comparatively dry and free from dust, but foreign material is liable to fall into it, the semi-inclosed type should be used. Where excessive dust or moisture prevails, the entirely inclosed motor should be used. The type last named is shown in Fig. 23.

Switchboards

Portable tools for shop use were spoken of at the beginning of this article. When the nature of the machine prohibits the mounting of the motor-controlling apparatus directly upon it, it is necessary to provide a portable mounting. Such an arrangement is shown in Fig. 24. The sketch in the upper part of the illustration shows a flexible cable for portable machine use, consisting of flexible rubber-covered conductors drawn into a fabric hose and the ends taped. This is serviceable and will withstand considerable rough usage.

In general, it is advisable to divide the wiring into separate feeder circuits for supplying the various groups of machines of the different departments and have each feeder controlled by means of a feeder switch. A simple and inexpensive feeder switchboard is shown in Fig. 25. It consists of wood strips supported on uprights upon which the switches are mounted. The wood should be well filled with oil and shellac.

The Starting and Operation of Air Pumps

By George H. Gibson

In a recent issue, L. A. Thompson asks why the Edwards air pumps used in connection with his steam-turbine surface-condenser units require more power when first started up than when running under high vacuum under full load, also why the centrifugal pumps supplying circulating water to the same condensers require less power when the tubes of the condenser are partly stopped up with shell fish than when they are perfectly free. These paradoxes are easily explained by paying attention to what goes on in the respective pumps. Let us take up the Edwards pump first.

By reference to the accompanying cross-section of an Edwards pump cylinder, Fig. 1, it will be seen that during the downward stroke the pressure on the upper side of the piston must be that due to the pressure of the water vapor corresponding to the temperature of the water left in the clearance space under the valves, while the pressure on the lower side of the piston will be that existing in the condenser.

With a high vacuum there will be practically no difference between these two pressures above and below and, therefore, the piston will do practically no work on the downward stroke, the only power taken by the pump being that required to overcome friction. On the other hand, if the condenser is still full of air as when first starting up, we will have the full pressure of the air on the lower side of the piston during the down stroke, while there will be a nearly perfect vacuum on the upper side as before. Consequently the work done on this stroke will amount to the area of the piston multiplied by the stroke, multiplied by the pressure in the condenser.

Now, take the up stroke. If there is a high vacuum the space above the piston will be filled by a mixture of air and vapor of about the same proportion as that in the condenser, that is, mostly vapor. There will also be a small amount of water. The vapor will be saturated and, when compressed on the up stroke of the piston, will begin to condense; but because of the small weight of the vapor

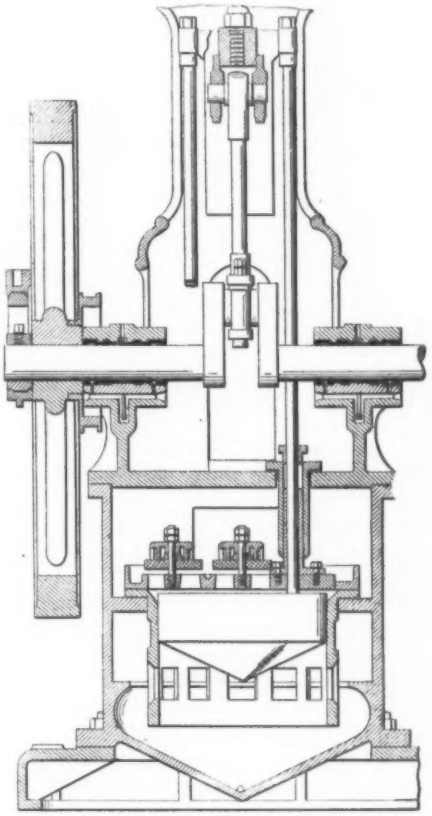


FIG. 1. SECTION OF EDWARDS AIR-PUMP CYLINDER—PLUNGER JUST FINISHING DISCHARGE STROKE

as compared with the weight and heat-absorbing capacity of the water present and of the cylinder, piston and rod, etc., the pressure will not be raised appreciably by the compression and condensation of the vapor. In fact, no rise in pressure is detected until the latter part of the stroke, when the entrained air begins to show itself. As only a small volume of air, figured to atmospheric pressure, is taken in at each stroke the marked rise in pressure will be brief and confined to the end of the stroke, and the area of the diagram produced will be correspondingly small.

But, if we suppose the condenser to contain a great deal of air, the rise in pressure will begin earlier, in fact, it will

run up to atmospheric pressure considerably before the piston reaches the end of the stroke, so that the pressure above the piston will considerably overbalance that below, calling for a corresponding expenditure of power by the motor.

From the above comparisons, it will be seen that more power is consumed on both the up and down strokes when a mixture rich in air is handled, as at first starting up, than when only water and steam and a very little air are drawn in, as at full load under a high vacuum. It should be noted that the increased load on the driving motor lasts only until the air in the condenser has been pumped out, and that as the overload is only temporary there is no difficulty through overheating of the motor.

Vac. 27.7"	G.P.M. 50.	Scale 20	R.P.M. 120
With 1/16" Orifice = 1.67 Cu. Ft. Free Air per Min.			

FIG. 2. INDICATOR DIAGRAM FROM EDWARDS AIR PUMP HANDLING VAPOR AND WATER WITH VERY LITTLE AIR

Vac. 25.8"	G.P.M. 50.	Scale 20	R.P.M. 120
With 2/16" Orifice = 15 Cu. Ft. Free Air per Min.			

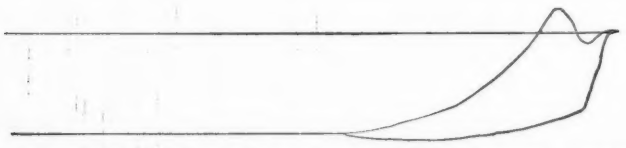


FIG. 3. INDICATOR DIAGRAM FROM EDWARDS AIR PUMP HANDLING SAME AMOUNT OF WATER BUT WITH 8½ TIMES AS MUCH AIR

The points just discussed are illustrated by the two indicator diagrams herewith, Figs. 2 and 3; one taken from a Wheeler-Edwards air pump handling 50 gallons of water with 1.67 cubic feet of free air per minute, and the other handling the same amount of water with 15 cubic feet per minute. The increased area of the diagram in the second case is very apparent, and it is interesting to note that in both cases very little rise of pressure takes place in the pump cylinder for nearly half the stroke, or during the initial period of vapor condensation. Another point nicely brought out by these diagrams is the fact that the pressure within the condenser is the same as the pressure existing within the pump chamber during the opening of the admission ports. This is due to the fact that the air and vapor are perfectly free to flow into this pump without overcoming the resistance of foot or bucket valves or of any water that might be lying above such valves. The pump, therefore, gets a full charge of vapor and gas at each stroke.

The Centrifugal Pump

In the case of the centrifugal pump, it is likewise not difficult to explain the increase in power consumption with increase of flow if we take account of what goes on.

When the condenser tubes are clean and free much more water is discharged by the pump through the condenser than when the tubes are stopped up with deposits. Suppose for the sake of definiteness, that we have a gate valve in the pump-discharge piping and that we shut it off tight, so that the pump can discharge no water at all. The pressure gage on this pipe will then show the maximum pressure which the pump is capable of giving at the given speed. Under these conditions, no water will pass through the pump impeller, which will simply revolve idly, carrying along with it whatever water it may contain. That is, it will be doing no work except to overcome the friction of the bearings and the friction between the impeller and the water against which it rubs in the pump casing. The water within the impeller, it is true, will be revolving at high speed, but once it has reached this speed it calls for no further power. If, now, we open our gate valve, some of this high-speed water will leave the impeller by flying off the periphery, while some new slow-speed water will enter the impeller at the suction inlet. In passing through the impeller the new water is brought up to high speed and it is this acceleration of new water all the time that requires power. Fig. 4 shows the decrease in available head and increase in power consumed by a centrifugal pump when the delivery of water is increased at constant speed.

To illustrate this idea, suppose we have a locomotive hauling 50 freight cars of 100 tons each along a level track at a speed of five miles per hour, and suppose further that the friction of the locomotive and cars takes 100 horsepower. Now, suppose that a line of freight cars are standing on the track ahead of the locomotive, so spaced, say, that the locomotive will run into them at the rate of 60 miles a minute, a suitable buffer being supplied so that this can be done without disastrous results. Further, to keep the friction load on the locomotive constant, suppose that at the moment that each car is picked up one car is uncoupled from the rear end of the train. Under these conditions how much more power

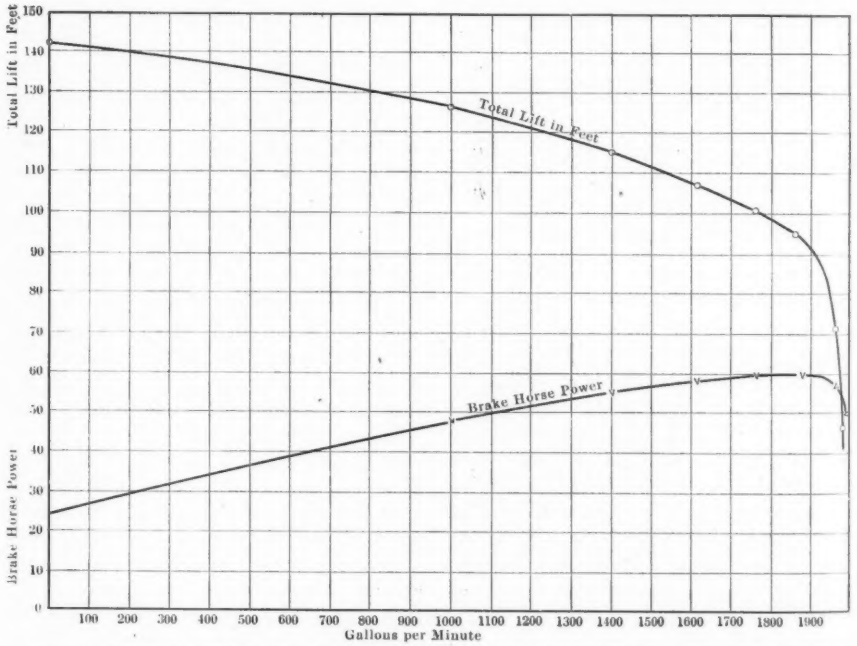


FIG. 4. SHOWING DECREASE IN AVAILABLE HEAD AND INCREASE IN POWER CONSUMED BY A CENTRIFUGAL PUMP WHEN THE DELIVERY OF WATER IS INCREASED AT CONSTANT SPEED

will the locomotive require than when drawing the train only? It is evident that the locomotive will be doing work in accelerating the new cars, and if we disregard the loss in shock, etc., this power can easily be calculated by the well-known formula,

$$Power = \frac{W V^2}{2 g},$$

W being the weight accelerated per second, V the velocity to which it is accelerated and g the acceleration of gravity, or 32.2. This will give us the power in foot-pounds per second and to get it into horsepower we can divide by 550. In the present example it works out as 302 horsepower. A similar action is going on in the centrifugal pump when it is delivering water, that is, it is all the time dropping water off at high speed from its periphery, and taking on new water at its suction to be accelerated up to speed and this work consumes the additional power. As in the case of the locomotive, the pump impeller should be designed to pick up its new load without shock.

Now, as to the fact mentioned by Mr. Thompson that his gage at the position shown registers a vacuum when the condenser tubes are free and open and the pump is delivering the maximum amount of water, and then a slight pressure when they are closed and the flow is restricted, can be explained as follows:

In a pump delivering at such low pressure as this one, most of the head to be overcome is that due to the suction and to the friction in the pump passages; moreover, as the discharge pipe from the condenser dips down again, and as the clean condenser offers little resistance to the flow of water, there will be enough

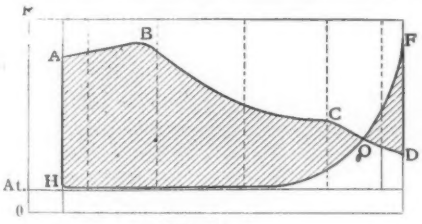


FIG. 5

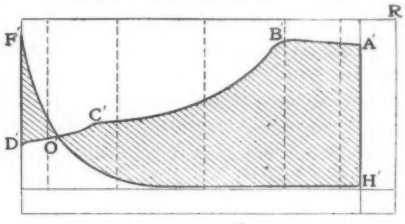


FIG. 6

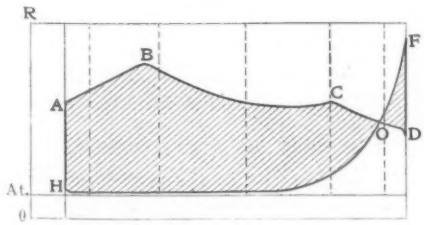


FIG. 7

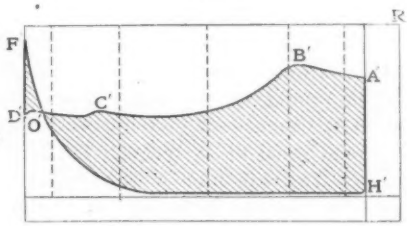


FIG. 8

siphon effect to give a slight vacuum at the point where the gage is attached. However, when the condenser tubes are plugged up and the flow of water reduced, the head consumed by friction in the pump will diminish and the pressure will pile up against the condenser tubes, where the resistance is encountered which would cause a higher gage reading.

Determination of the Best Weight of Reciprocating Parts in Steam Engine Design

By E. L. Weber

In this article a very simple and effective method is proposed for determining

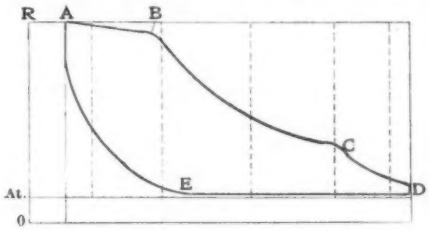


FIG. 1

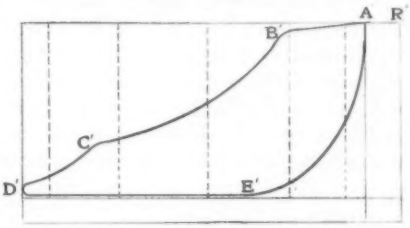


FIG. 2

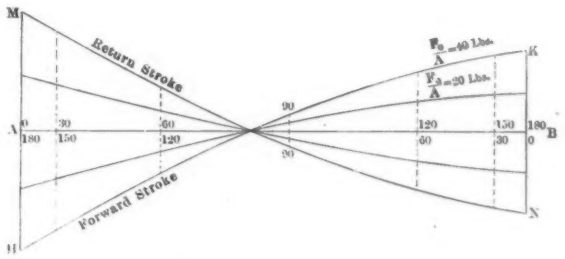


FIG. 3

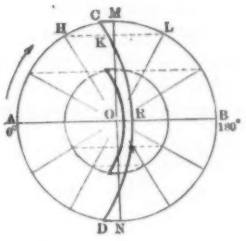


FIG. 4

the best weight of reciprocating parts for high-speed steam engines. This requires that the value of $\frac{F}{A}$, the retarding or accelerating pressure due to the reciprocating parts at any phase of the stroke, shall be such as to give the least variation in the tangential pressure on the crank pin.

Assume all preliminary calculations to be completed and the normal steam cards for the engine under design to be as shown in Figs. 1 and 2. The next step in the design is to construct acceleration diagrams for various assumed values of $\frac{F_o}{A}$, which is the centrifugal force due to a mass equal to the weight of the reciprocating parts concentrated in the crank-pin circle. It can be shown that

$$\frac{F}{A} = \frac{F_o}{A}\left(cos.\ \omega + \frac{R}{L}\ cos.\ 2\ \omega\right),$$

where

$\frac{F}{A}$ = The accelerating, or retarding, force per square inch of piston area at any part of the stroke;

ω = Corresponding crank angle,

$\frac{R}{L}$, = Ratio of the crank-circle radius to the length of the connecting rod.

Two such diagrams are shown in Fig. 3. One for $\frac{F_o}{A}$, equal to 20 pounds; the other for $\frac{F_o}{A}$, equal to 40 pounds.

An approximate geometrical method for constructing the acceleration diagrams is shown in Fig. 4.

Draw the circle $A\,B$, with radius $A\,O$ equal to 40 pounds on the same scale as was used in the steam-pressure diagrams of Figs. 1 and 2. Lay off $O\,R$, and the two tangents $C\,M$ and $D\,N$, each equal to $A\,O \times \frac{R}{L}$. For instance, if the ratio of the crank-circle radius to the connecting rod be chosen as 1 to 6, these lengths are equal to $1/6 \times 40$ pounds $= 6\frac{2}{3}$ pounds. Through C, R and D draw an arc of a circle. Then for $O°$ forward stroke

$$\frac{F}{A} = \frac{F_o}{A}\left(cos.\ O° + \frac{R}{L}\ cos.\ O°\right) = \frac{F_o}{A}\left(1 + \frac{R}{L}\right),$$

which is represented by $A\,O + O\,R = A\,R$ on the diagram. For 90 degrees forward stroke this equation becomes

$$\frac{F}{A} = \frac{F_o}{A}\left(cos.\ 90° + \frac{R}{L}\ cos.\ 180°\right) = \frac{F_o}{A} \times \frac{R}{L},$$

which is represented on the diagram by

$C\,M$. Similarly $R\,B$ represents the value of $\frac{F}{A}$ for 180 degrees forward stroke and $D\,N$ for 90 degrees return stroke.

For any intermediate crank angle, as $A\,O\,H$, the value of $\frac{F}{A}$ is represented by the intercept along the horizontal line included between the circle $A\,B$ and the arc $C\,R\,D$, or $H\,K$ in the present case. For the angle $A\,O\,L$ this force would be represented by $K\,L$, etc. Thus, in Fig. 3, $A\,H$ and $A\,M$ are equal to $A\,R$ of Fig. 4. $B\,K$ and $B\,N$ of Fig. 3 are equal to $R\,B$ of Fig. 4, etc. By using the smaller circle and arc of Fig. 4 the acceleration diagram for $\frac{F_o}{A} = 20$ pounds may be similarly constructed.

The acceleration diagrams of Fig. 3 are then combined with the steam diagrams of Figs. 1 and 2, to give the diagram of pressure on the crosshead pin. Figs. 5 and 6 show such a diagram, obtained by combining the steam card with the curves of acceleration for $\frac{F_o}{A}$ equals 20 pounds. The shaded areas represent the pressure. This is readily seen to be greatest at B, to pass through zero at O, and become negative beyond O. It will be noted that the line $H\,O\,F$ is the compression line $D'\,E'\,A'$ of Fig. 2. Fig. 6 is similarly constructed for the return stroke. Figs. 7 and 8 show cards obtained by using the value $\frac{F_o}{A} = 40$ pounds. These cards show a much more uniform distribution of pressure than was obtained in the preceding case.

We may now continue to draw cards of horizontal pressure on the crosshead pin for different values of $\frac{F_o}{A}$ and finally find such a value as will give the best results and the most even distribution of pressure.

In order to better analyze the effect of the reciprocating parts, it becomes necessary to convert the diagrams of horizontal pressure on the crosshead pin into diagrams of tangential pressure on the crank pin, as shown in Fig. 9.

To construct this diagram, draw the base line $A\,B$ equal to $\frac{\pi}{2}$ times the length of the steam card, and divide it into the same number of parts into which the steam card was divided. As this diagram represents rectified crank travel, the divisions are necessarily evenly spaced.

At these various divisions lay off the corresponding values of Fig. 5, converted into tangential pressures by the equation

$$t = P\,\frac{sin.\,(\omega + \alpha)}{cos.\,\alpha},$$

where

P = Horizontal pressure of Fig. 5,
ω = Corresponding crank angle,
α = Angle of the connecting rod with the piston axis,
t = Corresponding tangential pressure.

The curve $A\,D\,E\,F\,B$ results, and represents the tangential pressure on the crank pin during the forward stroke, with a value of $\frac{F_o}{A}$ equal to 20 pounds. In the same way the curve $B\,G\,J\,P\,A$ is constructed for the return stroke.

As the crank pin travels through a distance $\pi\,L$ during each revolution, whereas the piston travels through the distance $2\,L$, we have, by the equality of work done

$$\pi\,L\,t_m = 2\,L\,P_m,$$

or

$$t_m = \frac{2}{\pi}\,P_m = 0.6366\,P_m,$$

where,

t_m = Mean tangential pressure,
L = Length of stroke,
P_m = Mean effective pressure.

The ideal condition of absolutely smooth running of the engine would result if the tangential pressure were uniform and equal to t_m through the entire stroke. This condition is represented in Fig. 9 by the line $M\,N$, for the forward stroke, drawn parallel to $A\,B$ and at a distance $A\,M$ equal to t_m from it. $H\,K$ is the same line of mean tangential pressure for the return stroke.

This condition can never be realized in a reciprocating engine, but can only be approached by choosing such a value of $\frac{F_o}{A}$ as will give the least deviation from this line.

As is seen from Fig. 9, there exists an excess of power during phases I and III, and this excess is represented by the shaded areas $D\,E\,F$ and $G\,J\,P$. During phases II and IV an excess of resistance is present, which is represented by the shaded areas $F\,N\,B\,K\,G$ and $P\,H\,A\,M\,D$. As these areas represent work, by the principle of the conservation of energy, areas I and III must equal areas II and IV.

If tangential pressure diagrams are now drawn, with the value of $\frac{F_o}{A}$ varying, say, from 20 to 70 pounds, the excess of power, and resistance, will vary in these different diagrams, and we can readily find that value of $\frac{F_o}{A}$ which brings about the least divergence from the mean tangential pressure line.

As areas I and III equal areas II and IV, account need be taken only of areas I and III. Finding, with a planimeter, the sum of the areas I and III for different values of $\frac{F_o}{A}$, and plotting with areas as ordinates and values of $\frac{F_o}{A}$ as abscissas, the curve $A\,B\,C$, Fig. 10, is obtained. From the turning point B of this curve may be determined that value of $\frac{F_o}{A}$ which corresponds to the minimum area, or, that value of $\frac{F_o}{A}$ which produces the minimum excess of power, or resistance, and hence causes the smoothest running of the engine, for that particular card.

The advantages of this method of procedure lie in the fact that every possible value of $\frac{F_o}{A}$ receives full consideration, and by the process of mechanical integration the effect of the weight of the reciprocating parts is taken into account for every infinitesimal portion of the stroke.

Practical considerations frequently require that the weight thus determined be modified, but the method here outlined has the advantage that the best value of $\frac{F_o}{A}$ is accurately known, and the designer is free to approximate this value as closely as other limitations will permit.

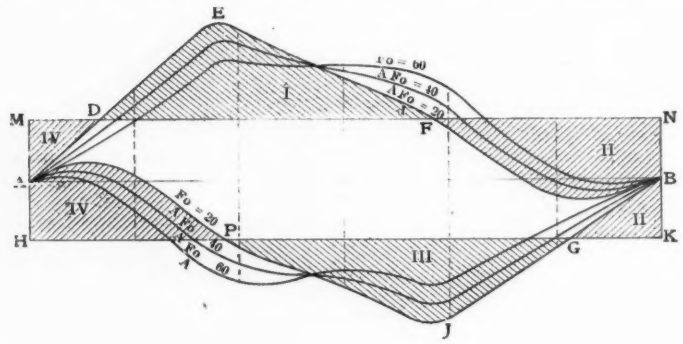


FIG. 9

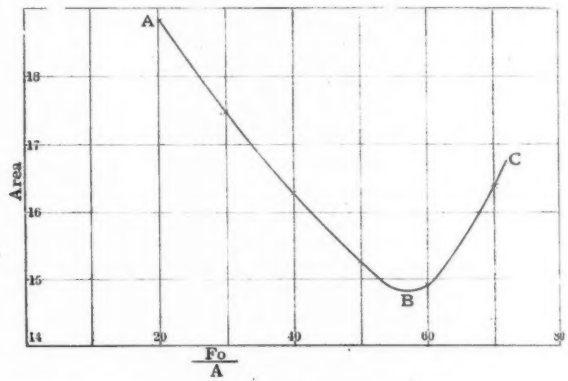


FIG. 10

Air Compression at High Altitudes

Why More Air Is Required to Do a Given Amount of Work, with Simple Methods of Calculating the Pressure Needed to Compress the Air

BY S. B. REDFIELD

Most users of compressed air are aware of the fact that at high altitudes, such as a mine located in mountainous country, a greater quantity of compressed air at a given pressure is required to do a given amount of work, such as rock drilling, than would be required to do the same amount of work at sea level.

Furthermore, the catalogs of the various makers of air compressors give lists of special compressors with extra large cylinder diameters, for altitude

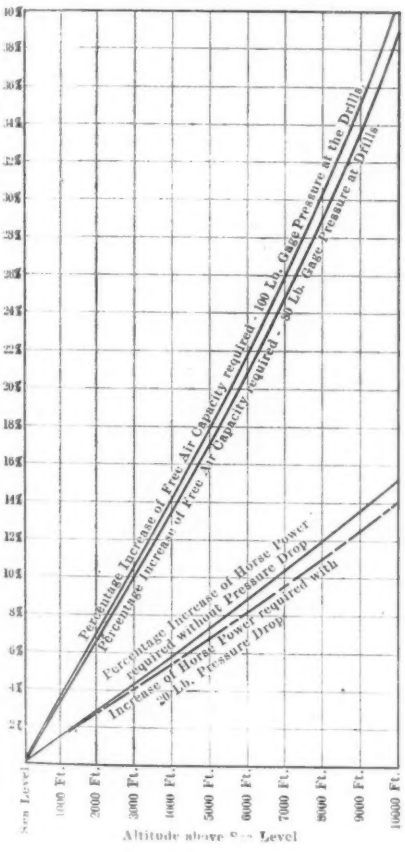

Percentage Increase of Free Air Capacity required - 100 Lb. Gage Pressure at the Drills.
Percentage Increase of Free Air Capacity required - 80 Lb. Gage Pressure at Drills.
Percentage Increase of Horse Power required without Pressure Drop.
Increase of Horse Power required with 20 Lb. Pressure Drop.
Sea Level
1000 Ft.
2000 Ft.
3000 Ft.
4000 Ft.
5000 Ft.
6000 Ft.
7000 Ft.
8000 Ft.
9000 Ft.
10000 Ft.
Altitude above Sea Level

FIG. 1

work. These tables show that the higher the altitude, the greater the volume of air that may be compressed to a given gage pressure with an equal amount of work. Thus it appears that while more air is required to do a given amount of work at a high altitude, more air may be compressed to a given pressure at that altitude with a given amount of power, and the question naturally arises as to whether or not these two effects neutralize each other with the result that the total actual amount of power required to do work at a high altitude may remain the same as at sea level. In reality these two effects do not neutralize each other, and in studying this question, the diagrams presented will serve to clearly show the actual conditions.

The "Reason Why"

Before arriving at final results, a study of the "reason why" will be of interest. In the first place, why does it take more air at a high altitude to do a given amount of work? The first and most obvious answer to this question is that the air is "rarer" at a high altitude. This is a good, general answer when air-operated machinery is viewed as a heat engine, but it does not give a sufficient explanation for most people.

Work is the product of a force through a distance. Suppose the working medium is compressed air, and, naturally, that it exerts its pressure against the face of a piston. Then the product of the air pressure by the area of the piston will give the "force," and the travel of the piston will give the "distance," resulting in work accomplished. Of course, the air must have a definite pressure, the piston a definite area and the travel must be defined in order to do a definite, measured amount of work. The actual air pressure which does the work is the difference between the absolute pressure on one side of the piston, and the atmospheric pressure on the other side; in other words, it is the gage pressure. Now it is the atmospheric pressure which changes at high altitudes and it is this that makes all the difference in air required and power developed.

As it is the gage pressure which actually does the work, a given gage pressure will exert the same force on an equal piston area at any altitude. For instance, 100 pounds gage pressure per square inch acting on a piston area of, say, 100 square inches, will exert a total force of 10,000 pounds, no matter what the altitude or atmospheric pressure may be.

This may be viewed in another way. At sea level, 100 pounds gage pressure will be 114.7 pounds per square inch absolute and acting on 100 square inches will exert 11,470 pounds pressure on one side of the piston, while the atmosphere will exert 14.7 pounds per square inch absolute on the other side, or 1470 pounds pressure. The resultant force is 11,470 — 1470 = 10,000 pounds urging the piston on. If the altitude were 8000 feet above sea level and the atmospheric pressure were 10.9 pounds absolute, 100 pounds gage pressure would be 110.9 pounds absolute, and acting on 100 square inches of piston area the total force exerted would be 11,090 pounds, while the atmosphere on the other side would exert a pressure of 10.9 pounds per square inch, or 1090 pounds upon the back of the piston. The resultant force is 11,090 — 1090 = 10,000 pounds tending to move the piston, as before.

From this it is seen that the change in atmospheric pressure due to altitude has no effect whatever on the net force exerted upon a given piston area by a given

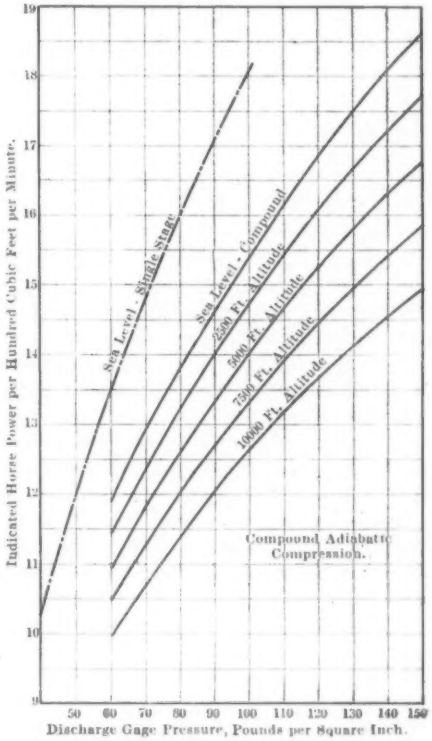

Indicated Horse Power per Hundred Cubic Feet per Minute.
Sea Level - Single stage.
Sea Level - Compound.
2500 Ft. Altitude.
5000 Ft. Altitude.
7500 Ft. Altitude.
10000 Ft. Altitude.
Compound Adiabatic Compression.
Discharge Gage Pressure, Pounds per Square Inch.

FIG. 2

gage pressure. Then why is more air required to do work at a high altitude? The cause lies in the volume of the compressed air. The quantity of compressed air required to fill a given space depends upon the pressure of the air, and it is the absolute pressure to which it is directly proportional.

Again, let us assume 100 pounds gage pressure and 100 square inches of piston area and let the distance moved through be 1 foot. Then no matter what the altitude, the total force exerted will be

10,000 pounds, as already shown, and moving through 1 foot of distance the work performed will be 10,000 foot-pounds. The quantity of free air required to do this work nonexpansively will be the volume of the cylinder multiplied by the absolute ratio of compression of the air, or the number of times it has been compressed. At sea level, the ratio of compression would, in this case, be 114.7 ÷ 14.7 = 7.8. The volume of the cylinder we are considering is 1200 cubic inches, or 0.694 cubic foot, so the total quantity of free atmospheric air that would be used at sea level would be 0.694 × 7.8 = 5.42 cubic feet.

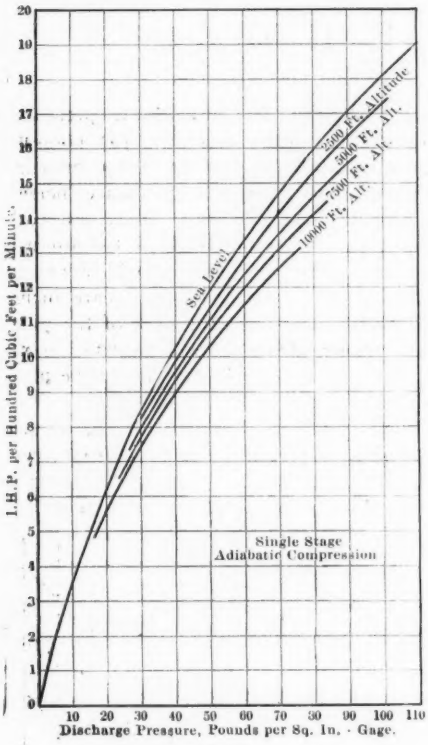


FIG. 3

If this had been done at, say, 8000 feet altitude, and the atmospheric pressure were 10.9, the ratio of compression would have been 110.9 ÷ 10.9 = 10.16. Then the total quantity of free atmospheric air that would have been used at 8000 feet altitude would be 0.694 × 10.16 = 7.05 cubic feet.

By this it is seen that while at sea level 5.42 cubic feet of free atmospheric air acting at 100 pounds gage pressure will do 10,000 foot-pounds of work, it will require 7.05 cubic feet of free air to do the same work acting on the same piston at 8000 feet altitude. This is an increase of 30 per cent. of free air or piston displacement of compressor required and is, of course, based on nonexpansive operation, as is usually the case with air-operated machinery.

Power Required to Compress the Air

Now to look at the matter of the power required to compress this increased quantity of air at a high altitude. The formula for the power required to compress 100 cubic feet of free air per minute to any pressure is for single-stage compression:

$$\textit{Indicated Horsepower} = 1.51\, p_1 \left(R^{0.29} - 1 \right).$$

For compound compression the formula is:

$$\textit{Indicated Horsepower} = 3.02\, p_1 \left(R^{0.145} - 1 \right).$$

In these formulas p_1 is the absolute initial pressure per square inch at the inlet to the compressor, usually that of the atmosphere, and R is the ratio of compression, or the absolute discharge pressure divided by the absolute initial pressure. This shows that the power required to compress a given cylinder volume of air to any pressure depends upon the initial or atmospheric pressure. As this factor appears in the formulas both outside the bracket, to the first power, and also in the ratio of compression raised to a fractional power, it is plain that the power required will not vary in a simple ratio with the intake or atmospheric pressure. As the quantity of air required to do a certain amount of work does vary directly with the ratio of compressor, which is dependent upon the atmospheric pressure, it is clear that the one does not increase at the same rate at which the other decreases and the net result of power required to do a certain amount of work by compressed air will vary with the atmospheric pressure and therefore with the altitude.

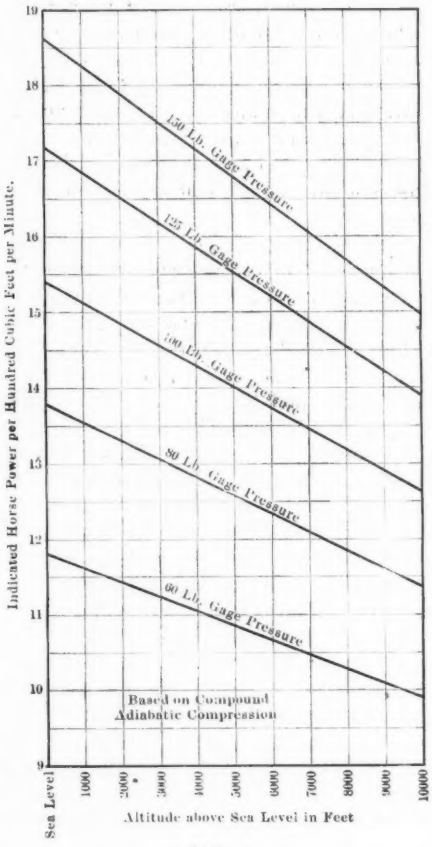

Indicated Horse Power per Hundred Cubic Feet per Minute.
150 Lb. Gage Pressure
125 Lb. Gage Pressure
100 Lb. Gage Pressure
80 Lb. Gage Pressure
60 Lb. Gage Pressure
Based on Compound
Adiabatic Compression
Sea Level
Altitude above Sea Level in Feet

FIG. 4

By figuring out the amount of air required and the amount of power required to compress this air, to do a given amount of work, at various altitudes, it will be found that the higher the altitude the more power it will take to do this work. Of course the pressure of the air has some bearing on the subject, but it is a fact that within the limits of usual pressures employed, the increase of power varies very little with the air pressure, at a given altitude.

The curves given in Fig. 1 show how the free air, or compressor-piston displacement, and the power required increase with the altitude. The increase is given in percentage of that required at sea level. The curves of piston displacement increase are calculated with both 100 pounds and 80 pounds gage pressure at the drills, and the curves of power increase are calculated with 100 pounds gage pressure at the compressor, as a basis. It should be understood that this latter pair of curves does not show the change in power required to compress a given amount of air, but that it does show the increase of power required in the compressor to do a given amount of work in such a device as a rock drill, or other reciprocating machine, operated by compressed air without cutoff or expansion. The full-line power curve shows theoretical results, counting or using the air in the drill at exactly the same pressure as that of the compressor discharge, or in other words, without pipe-line pressure drop. The broken line is calculated on a basis of using the air in the drill at a pressure 20 pounds below that of the compressor.

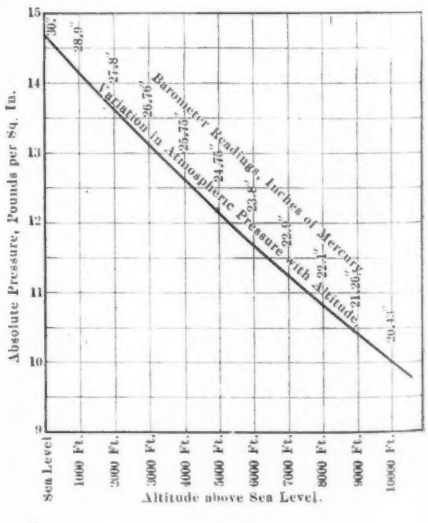

Absolute Pressure, Pounds per Sq. In.
Barometer Readings, Inches of Mercury
Variation in Atmospheric Pressure with Altitude
Sea Level
Altitude above Sea Level.

FIG. 5

From these power curves it appears that at 10,000 feet altitude, with no pressure drop, the power required is 15.2 per cent. more than at sea level, while if 20

pounds pipe-line pressure drop is allowed, the increase is about 14.1 per cent. At 5000 feet altitude, these figures are 7.25 and 6.85 per cent., respectively. This statement is liable to raise a misunderstanding, for it seems to show that a pressure loss in the pipe line is an advantage, which is against common-sense reasoning.

As a matter of fact, the full-line and broken-line power curves in Fig. 1 should not be compared with each other, for any point on either curve is relative to other points on itself only. The actual power required at any altitude with 20 pounds pressure drop in the pipe line is, of course, more than that required without any pressure drop, but at a higher altitude the *increase* of power required, due to that altitude, is less than when there is none. This is easy to see when it is remembered that a given measured increase of power would be a smaller percentage of the larger power, and it is, of course, advisable to have as little pressure loss in the pipe line as is possible. The curves are figured on compound compression because this is the most usual, especially for altitude work, where the ratio of compression increases considerably, giving rise to high cylinder temperatures.

The most useful feature of this discussion will be found in Figs. 2, 3 and 4, where curves are plotted to show how the indicated horsepower required to compress 100 cubic feet piston displacement of free air per minute varies with the pressure at different altitudes, and also how it varies with the altitude at different pressures. These two sets of curves viewed together reveal the rather curious fact that although the indicated horsepower at a given altitude varies with the pressure in a curved line, the variation with the altitude at a given pressure looks like a straight line (Fig. 4).

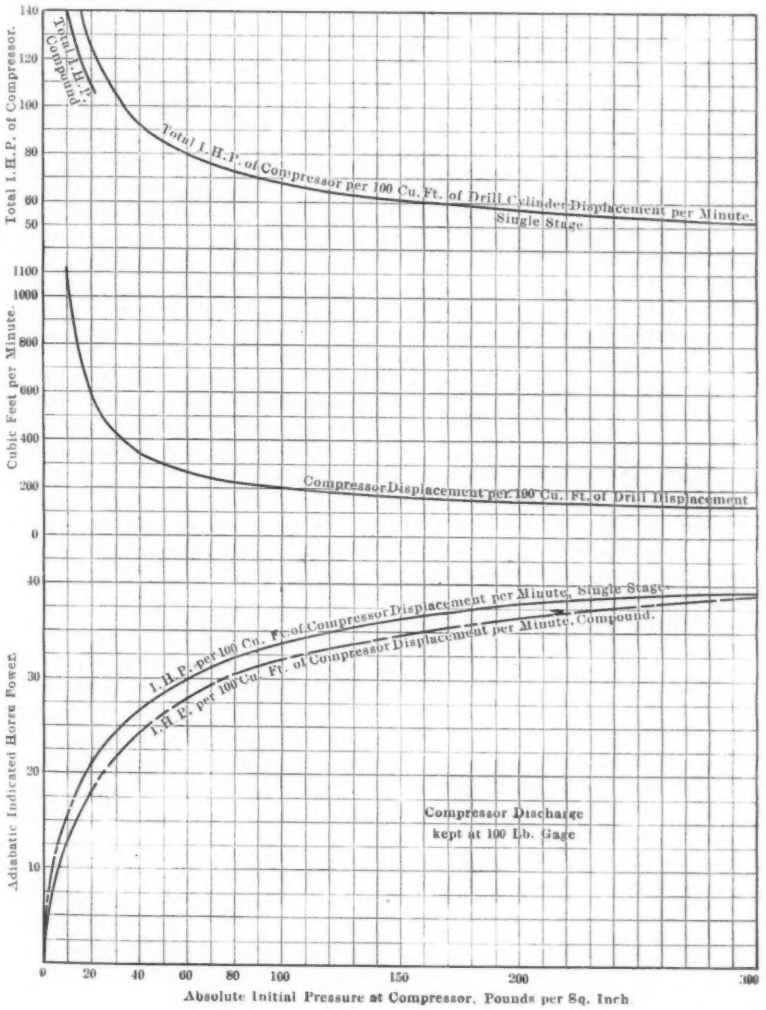

Total I.H.P. of Compressor.
Total I.H.P. Compound
Total I.H.P. of Compressor per 100 Cu. Ft. of Drill Cylinder Displacement per Minute, Single Stage
Cubic Feet per Minute.
Compressor Displacement per 100 Cu. Ft. of Drill Displacement
Adiabatic Indicated Horse Power.
I.H.P. per 100 Cu. Ft. of Compressor Displacement per Minute, Single Stage
I.H.P. per 100 Cu. Ft. of Compressor Displacement per Minute, Compound.
Compressor Discharge kept at 100 Lb. Gage
Absolute Initial Pressure at Compressor, Pounds per Sq. Inch

FIG. 6

These lines are, however, not straight, for when the calculations are carried through a wider range of intake-pressure variation, it is found that the lines begin to curve to a very marked degree. This is shown in the two lower curves of Fig. 6. In this figure, horizontal distances represent absolute initial pressure at the compressor intake and the marking on the various curves clearly indicates what they each represent. All the calculations illustrated in Fig. 6 are based on 100 pounds gage, compressor-discharge pressure, assuming the atmospheric, or initial-intake pressure, to vary from zero, or absolute vacuum, to a maximum of 300 pounds absolute.

These curves, then, may be taken to show what would occur in caisson work, where drills are operated in an atmosphere denser than that existing in nature, assuming that the drill compressor draws its air supply from the caisson itself. As before stated, the working pressure is 100 pounds gage at all times; that is, a pressure gage placed in the dense atmosphere, and connected to the compressor discharge would always read 100 pounds no matter what the absolute pressure of the atmosphere in the caisson. For instance, when the absolute pressure of the caisson atmosphere is 20 pounds, the absolute compressor discharge is 120; when it is 50 pounds the absolute compressor-discharge pressure is 150 pounds, and when the atmosphere is at 200 pounds, the discharge pressure is 300 pounds absolute. Of course, in practice, caissons are seldom or ever operated with an atmosphere above 40 pounds gage, or 55 pounds absolute, 50 for actual conditions, the curves in Fig. 4 could have been limited between an initial pressure of 10 pounds absolute, for 10,000 feet altitude work and 55 pounds absolute for the heaviest caisson work. However, the calculations were extended from zero to 300 pounds absolute-initial pressure simply to show the trend of the curves.

It will be seen that the curves of the indicated horsepower per 100 cubic feet compressor displacement for single-stage and compound compression both start at zero indicated horsepower, with zero atmosphere, or absolute vacuum, and as the atmospheric pressure increases they diverge considerably, well showing the saving by compound compression. However, as the atmospheric pressure increases and the ratio of compression becomes less and less (at 14.7 pounds absolute-initial pressure the ratio of compression is 7.8 and at 300 pounds absolute-initial pressure it is only 1.5, assuming always 100 pounds gage discharge pressure), the two lines again come nearer and nearer each other, until they meet at infinity.

Above these two indicated horsepower factor curves is another curve showing the compressor displacement required per 100 cubic feet of drill-cylinder displacement, under what might be termed extended caisson conditions. Above this again, are curves showing the total indicated horsepower required in the compressor per 100 cubic feet of drill-cylinder displacement per minute. This drill displacement may be taken as the measure of the actual work done by the air in the drill, because the working pressure is assumed to always remain at 100 pounds gage. All these lines then show the various requirements of air and power to do the same amount of work in the drills, as the caisson atmosphere is varied from vacuum to 300 pounds absolute.

Assuming single-stage compression, it appears that while the total compressor indicated horsepower per 100 cubic feet of drill displacement per minute is 142 when the atmosphere is at 14.7 pounds absolute, or normal, the compressor power required is only 82 indicated horsepower, or 58 per cent. of this, when the caisson atmosphere is 55 pounds absolute, or 40 pounds gage. Comparing the power required at 55 pounds absolute caisson pressure by single-stage compression with compound compression at 14.7 pounds absolute-atmospheric pressure, we have 120 for the latter, and 82 for the former, and 82 is 68 per cent. of 120. Compound compression would not pay for an atmosphere above 20 pounds absolute, with 100 pounds gage working pressure, because the ratio of compression becomes too small.

As a matter of fact, in actual caisson work, the compressors driving the drills usually draw their air supply from the natural outside atmosphere and thus add their output, through the drills, to the air being pumped directly into the caisson. It would at first appear that they would save considerable power by drawing the air for the drills from that in the caisson, thus using it over and over again, but of course just exactly the amount of air used by the drills would have to be pumped into the caisson by the low-pressure compressors, to keep out the water, so nothing would be saved by this means after all.

Some attempts have been made to apply this high intake-pressure method of operation to the driving of drills and pumps, and much calculation and writing has been done on the subject, which is known as the "dense-air system." Its theoretical savings are indeed attractive, but it is a difficult system to govern, not being flexible, and the troubles with leakage in the double pipe lines, and many other difficulties, have prevented its extensive adoption. There are, however, some large examples of its use in the South African mines, at the present time.

The curves given in Figs. 2, 3 and 4 will be found useful for figuring the power required to drive a compressor of a given size at any altitude from sea level to 10,000 feet elevation. The figures give theoretical adiabatic indicated horsepowers developed in the compressing cylinders, per 100 cubic feet of piston displacement per minute, and to these should be added about 12 per cent. for a steam machine and 20 per cent. for belt driving, to allow for mechanical efficiency of the moving parts of the machine, belt, etc.

Fig. 5 shows the variation in atmospheric pressure with altitude, from which the other curves were figured. Of course, weather conditions affect the atmospheric pressure quite materially, but the curve is meant to represent average fair-weather conditions.

Fig. 6, while not of direct commercial use, will prove of interest in showing what occurs under various conditions of intake-pressure variation, and if it sheds any additional light on the somewhat complicated subject of air compression, its calculation will not have been made in vain.

Water Hammer in Pipes

By Samuel K. Patteson

The phenomenon of water hammer, so-called, in both steam and water pipes is more or less familiar to the average designing and operating engineer. The magnitude of its effect, however, in all the different types of pump and engine connections and the special methods of its elimination or alleviation are not so familiar. The general phenomenon is well known. Water given or possessing a velocity and brought suddenly to rest exerts a force, and often a destructive one, upon surrounding objects, but the size of this force and the conditions governing its maximum effect and the methods of calculating it are not as well known as they should be. Water-hammer effects can be divided into two classes, dependent upon the nature of the system in which they occur. Thus we have water hammers in water piping and water hammers in steam piping. Each can be made very destructive under special conditions. In actual practice the accidents resulting from water hammer in steam pipes are much more common than those from water hammer in water pipes. The reason for this is obvious. Water hammer in steam pipes is an incidental phenomenon, whereas water hammer in water pipes is an inherent evil and must be regularly allowed for in the design and construction.

A moving column of water possesses kinetic energy, as does any other moving body. Its energy, measured in foot-pounds, can be calculated by the formula

$$E = \tfrac{1}{2} \frac{W V^2}{g},$$

where

W is the weight of the water in pounds,

V is the velocity in feet per second and

g is the acceleration due to gravity in feet per second.

From an inspection of this formula, it can be readily seen that the total energy of a moving body increases with great rapidity with increase in velocity. When the velocity of a given body is doubled, the energy that it possesses is increased four times. Another method of expressing the same relation is by saying that a pound of water moving 10 feet per second possesses the same energy as 100 pounds of water moving 1 foot per second.

Now, when such a column of moving water is stopped suddenly or retarded, the force that it can exert is equally capable of determination with comparative ease and a fair degree of accuracy. The formula governing such transfers of energy is what is known as the impact and momentum relation and is

$$W\ (V_1 - V_0) = f\ t.$$

If the quantity $(V_1 - V_0)$ is the difference in velocity of the water acquired during change in motion and t is the time during which this change occurs, then f is the force exerted by the moving body on the resisting obstruction. This formula, while comparatively simple, is one of the most difficult in physics and engineering practice for the average mind to grasp in its full significance. In fact it is often taught wrong in various schools and textbooks, as can be readily seen from the following type of question which often exists and for which a numerical answer is often required: "How hard does a body hit when it is going at such and such a velocity and is suddenly brought to rest, or is made to rebound with such and such a velocity?" The force exerted in an example of this type is dependent simply upon the time required in stopping. A baseball, when stopped by a rigidly extended arm, exerts a tremendous force, whereas, when gradually retarded and brought to rest slowly by the same means, the force is scarcely appreciable.

Elimination of Water Hammer

From the foregoing, one can readily see the nature of water-hammer effects and make a fairly good guess at the methods of its elimination. One method is to retard the moving column of water slowly. Another method, if the water is stopped suddenly, is to supply a suitable buffer, which in nine cases out of ten employs exactly the same method as the slow mechanical retardation. Another method is to eliminate, as far as possible, high velocities in pipes, especially where considerable weight is involved in the moving material. Thus, water hammer in steam and water pipes is essentially different. The water-hammer effect in steam pipes is invariably caused by the presence of water of condensation from the steam, which is collected either during operation or over night during periods of shutdown. The small mass of water involved in this phenomenon may acquire a very great velocity, due to the high steam pressure often behind it, and the presence of the vacuum in front. Steam going into a vacuum travels at a speed of about 1900 feet per second. This velocity, of course, is diminished when it is compelled to push the water, which of its own accord, in atmospheric condensers, will travel into the vacuum at the rate of about 47 feet per second, when pushed by atmospheric pressure. Of course, this latter figure may vary considerably, dependent upon the length of time the force

acts on the moving water, but that is the average figure in ordinary steam condensers, as obtained by using atmospheric air pressure to cause the introduction of condenser water. On the other hand, water in water pipes generally is limited to a flow of about 2 feet per second in some installations, and the limit, or rather the actual working figure, in plumbing and other installations is considered in the neighborhood of 3½ feet. However, in many waterworks the necessity of having a sufficient pressure to furnish a supply of water to a considerable distance and at various levels often results in a considerable pressure and a much higher velocity of the water when allowed to flow at intermediate points. The one limitation that permits actual working under these conditions is due to the fact that generally comparatively small quantities of water are used under such conditions, and the quantity of water actually in motion at any one time at this velocity is comparatively small.

Water Hammer in Steam Pipes

First, in regard to the consideration of water hammer in steam pipes. The possibility of its presence is always at hand, and the capabilities of disastrous results in a given installation are in direct proportion to the steam pressure used. Steam engines of the reciprocating type are more or less subject to this danger, since they possess possibilities of transmitting the steam pressure to water columns in the connected piping at irregular intervals, and by means of the moving piston and the valves are equally capable of stopping the motion of a given column of water with considerable rapidity. Thus water can collect in the pipes on both sides of an engine cylinder. When on the boiler side, the starting of the engine gives the water a velocity toward it almost equal to that of the steam. The velocity of such a mass of water may be instantly stopped in this flow into the engine under these circumstances by the operation of the valve, and disastrous pressures result, since these types of engine are in general only designed to withstand steam-hammer effects at this point. These latter are comparatively slight, although of the same character as that involved in the water phenomenon. In general, the stoppage of a moving column of steam, on account of the small mass, can be neglected in actual practice, unless it has velocities much greater than those generally occurring in actual conditions.

Definite arrangement for the elimination of water by means of steam traps and other devices generally exist at this point for an entirely different reason, and thus generally eliminate the possibility of water hammer on this side of the system. The injection of a certain quantity of water into the cylinder of a rapidly moving engine is invariably followed by disastrous results, due to the almost total incompressibility of water and the fact that the piston is moving at a fairly high rate of speed. The water cannot get out fast enough and the piston cannot stop quickly without exerting a tremendous force, and the result is usually that the cylinder head is knocked out. This in reality is a phenomenon similar to that of water hammer, when it involves the actual stoppage of the piston itself with great rapidity. On account of the possibility of this occurrence, the presence of water on this side is closely guarded against and water-hammer effects are practically unknown, unless a branch connection exists at this point for heating purposes with high-pressure steam. This latter connection is the chief cause of accidents in this field. However, when the steam goes through the engine, it may possess sufficient pressure to act on a column of water entrapped in the remaining pipe system. This water can acquire a fairly high velocity in a short time with a comparatively small steam pressure, since generally a vacuum exists at the other surface.

Water-hammer effects are readily transmitted around elbows and through traps, if these contain sufficient water for the transmission of hydraulic pressure. The effect of elbows, bends or angles in a piping system is primarily to retard the rate of flow, and this retardation is not proportional to the velocity, but varies as the square or some higher power of the velocity. Hence, it is a kind of safety valve or brake which acts more and more strongly as a retardation as the velocity increases. Practical effects of water hammer differ in this regard with each velocity and each installation. Straight pipes permit of a more rapid motion for a given force, and, if the velocity is great, the moving column of water acts more like a rigid body on impact than like a liquid, and hence transmits pressure or force directly along the line of travel. As a general thing the disastrous effect can be considered directly proportional to the length of straight pipe involved, which is filled with water in motion, other things being equal.

Water Hammer in Water Pipes

This, while essentially the same phenomenon, possesses, under certain circumstances, radically different effects on account of different values of the quantities involved. As a general thing large quantities of water are in motion and the velocity is nowhere near as great as in the preceding case. Conditions for hydraulic pressure transmission are much more likely to exist and the effects at elbows or changes in direction, as dependent upon mass and velocity, are often very different. Pumps of the reciprocating type in their action possess on both sides possibilities for the existence of water hammer, due to the same reasons as exist in steam-engine operation. The piston moving in the cylinder at a fair rate of speed puts the water in motion in the pipes on both sides of the system; that in the suction pipe, acquiring a fair degree of velocity, is brought to rest quite suddenly by the action of the valve. The elimination of this effect, which is often quite pronounced for even moderate speed pumps, is accomplished by a large increase in the size of the suction pipe, hence diminishing the velocity of the water, for a given output, into the cylinder. Since the energy of the water in motion is directly proportional to its mass and varies as the square of the velocity, an increase in the mass, with the corresponding diminution in velocity, results in an equal output, but a much smaller amount of effective energy is stored in the moving column. The force exerted by water hammer in pumps of inadequate design is often enormous.

Water-hammer effect is equally present on the pressure side of the pumping system. When water is raised a considerable hight, and there is a large quantity of water set in motion at each stroke of the piston, two different effects exist. The water set in motion will go on and rebound, possibly in time to catch the water on the next stroke moving in the opposite direction, thus exerting a tremendous force, or possibly getting into heavy periodic vibration. If the speed of the pump and the hight of the water column are suitably arranged, these resonance effects can be most pronounced and result in the destruction of the system, whereas at another speed the effect would be scarcely noticeable. On the other hand, the piston acquires its maximum motion in the cylinder quite rapidly during each stroke, and if the large quantity of water on the pressure side must be given this velocity, it possesses sufficient inertia to require enormous forces in the piston. Hence follows the installation of the buffer or air chamber in the pressure side of the pipe system in an average pump. It serves two purposes. It acts as a buffer for back water-hammer effects, and it acts equally as a buffer or shunt for piston-stroke effects. The water driven by the piston into the pressure side of the pump meets what is equivalent to a stone wall in the inert mass of water content in the pipe. It gets shunted into the air chamber and compresses the air with comparative ease or by the exertion of a definite known force. This force returned by the air is sufficient to keep the water column in comparatively steady motion throughout the period of the pumping stroke.

An interesting effect of water hammer and one in which the phenomenon is made quite pronounced is present in the hydraulic ram or pump. When it is considered that the water service in the majority of towns often undergoes effects practically equal to this, or even greater, on cutting off a supply of water, the result of the effect and its importance can be readily seen.

A Link Motion Designed and Analyzed

A Method of Exact Design for Drafting Room Use; also a Consideration of Just How the Link Acts and How a Short Cutoff Is Produced

BY FRANK W. MERRILL

The slide valve is a poor piece of mechanism to use in obtaining a short cutoff. It is used for just this purpose, however, in locomotive and automobile work, in connection with a device known as the Stephenson link inserted between the eccentric rods and the valve rod. The link-driven valves give satisfaction in practice, but there is always present that very undesirable condition of restricted port opening and enormous compression, which invariably accompany the use of the slide valve in producing an early cutoff. The motion of this link in its different positions is peculiar in the extreme, and the exact method of its action is hard to understand without careful analysis.

It is the intention of the author to show the method of designing the link motion for the engine referred to in a previous article on "Slide Valve Design," and demonstrate by the use of the valve diagram and a set of curves, plotted from the exact motion of the link itself, just how it is that the link is able to produce a short cutoff, and show how the influence of the forward and reverse eccentrics upon the valve motion varies as the link is moved over from forward to reverse positions.

General Arrangement of the Link

In Fig. 1 is an assembly of the link, with the forward and reverse eccentrics and the accompanying levers and mechanism necessary to a complete understanding of the principles involved. In the lower part of the figure is the eccentric circle $a'' c''$, the center of which is the center of the crank shaft. The center of the forward eccentric is at F, and the center of the reverse eccentric is at R. The angle $a'' O F$ equals the angle $a'' O R$, and the angle of advance is the same for each eccentric. In automobile work both eccentrics are commonly made in one piece and keyed in the proper position on the crank shaft, so that it is out of the question to shift the eccentrics or to change the angle of advance after it has once been determined. The forward and reverse eccentric rods connect to the bearing pins F and R of the link.

In this case the link consists of a solid slotted bar curved so that the radius of the center line of the slot, which is called the link arc, is equal to the length of the eccentric rod plus the radial distance from points R or F of the link to the link arc. The valve rod terminates at its lower end in a clevis which forks over the link and is pivoted to the link block. The valve rod and clevis can only move up and down on their center line $A B$, and as the link rocks back and forth, its curved slot slides on the block and draws the latter up or down in accordance with the vertical component of the rocking motion. This motion is transmitted to the slide valve at the upper end of the valve rod.

The method of suspending or hanging the link has a very great influence upon the subsequent action of the mechanism, and this part of the design is fully as important as the correct design of the link itself. In this case the link is pivoted from a point S in the link arc produced, and is supported by a bar $S M$ called the link hanger. This bar is pivoted at the point M at one end of the bell-crank lever $N T M$. The lever turns about the point T as a fulcrum, and a direct push or pull on the rod connecting with the reverse lever will cause the point M to travel back and forth on the arc $D E$. When the point M is at the point on the arc marked "full gear forward," the link is drawn back so that the point of attachment F of the forward eccentric is brought directly under the link block, and the valve is given its motion entirely by the forward eccentric. Now if the rod be pulled out so that point M travels around to the point marked "full gear reverse," the link will be pushed to the right and the point of attachment R of the reverse eccentric will be brought directly under the link block, and the valve will be given its motion directly by the reverse eccentric.

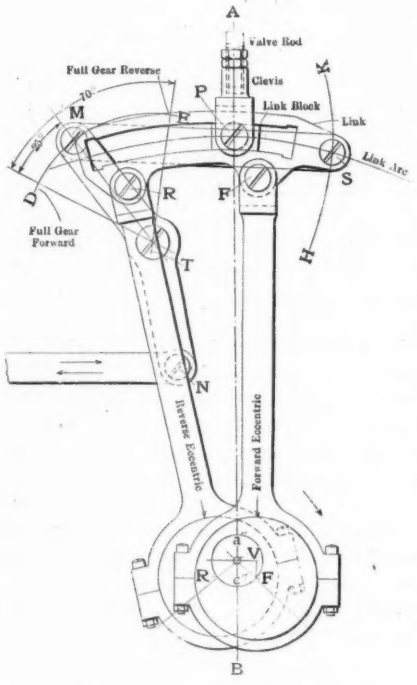


FIG. 1. THE LINK ASSEMBLED

Somewhere — approximately half-way between these two positions—is a neutral point called the dead center, and when point M is there, both eccentrics will have equal influence on the valve, which will slide up and down over the ports a distance equal to

$$2 F V = 2 R \sin \text{angle of advance},$$

where R = the radius of the eccentric circle $a'' c''$. This will be the smallest possible valve travel, and the less the angle of advance, the less will be the motion of the valve in the dead-center position. If the angle of advance is small, the valve may simply slide back and forth without uncovering the ports; and if it is large, the ports may open slightly and a little live steam may blow through into the exhaust, but the engine will not run.

Sometimes the point S is placed above the link arc and at an equal distance from each end of the link. If this is done, the imperfection of the motion will be the same on the forward and reverse positions, but, as it is here placed, the motion on the forward position will be nearly perfect, while the entire error will appear when the link is operating "full gear reverse." This is the best plan for all ordinary purposes, as the engine is seldom reversed and then only for a short time.

To sum up, the direct train of mechanism with which we have to deal consists of two eccentrics, two eccentric rods, the link and the link block, clevis, valve rod and valve. In connection with the link we have a link hanger, one end of which furnishes a support for the link at point S, which moves up and down in the arc $H K$, as the link rocks to the motion of the eccentrics. The link hanger is pivoted at point M, which is stationary for any one notch of the reverse lever, but which point moves in arc $D E$ as the reverse lever is shifted. In Fig. 1 the link is shown with point M moved 25 degrees from the full-gear-forward position. This is a proper setting of the link for high

forward speed, small torque, short cutoff and restricted port opening. It has been the purpose so far to show the general nature of the problem presented; it will now be shown how the link motion may be analyzed and what conditions must be complied with to obtain a good design.

Link Motion Analyzed

Fig. 2 is a diagram of the link mechanism in two positions, and in addition to this there are five other figures which are numbered in small circles placed in or near them. In the general diagram is shown, instead of the link itself, an exact copy of the templet used in this kind of design. The centers of the pins *R*, *F* and *S* are represented by the extreme points of the three projections on the templet, and the link arc is represented by a narrow slit cut in the templet. The length of this slot is such that its ends mark the extreme safe limit of travel of the center of the link block—it is usual to allow the block to run over the shoulder at either end of the link slot and then allow a certain amount of clearance between the block and the end of the slot, but that is a matter of mechanical detail and cannot be further discussed here.

The arc *C J* represents the path of the point *S* when the link is in full-gear-forward position; the arc *G I* represents the path of point *S* when the link is in the full-gear-reverse position. Point *M* is the center of arc *C J*, point *M'* is the center of arc *G I* and point *M''* is the center of arc *H K*, the arc corresponding to the 25 degree-forward position shown in Fig. 1. The radius of these three arcs is equal to the length of the link hanger. The two positions, *M T N* and *M' T N'*, of the bell-crank lever should also be noted.

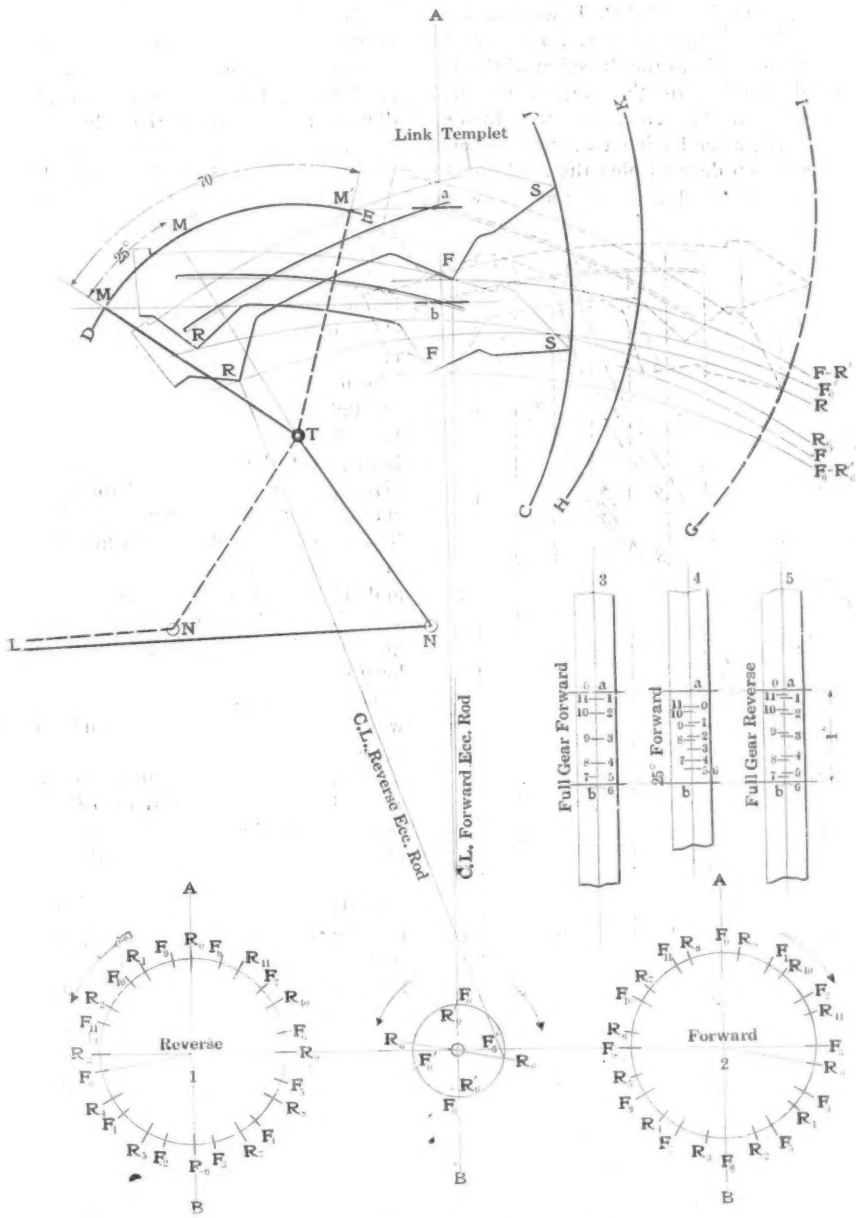


FIG. 2. DIAGRAM OF THE LINK MECHANISM

In both the full-gear-forward and full-gear-reverse positions the link has been shown in two parts of its rocking motion, namely, the extreme upper and the extreme lower limits of the travel of the valve. When the center of the link block is at point *a*, the valve is in its highest position, and when it is at point *b*, the valve is in its lowest position. Distance *a b* on line *A B* represents the travel of the valve, which in this case is 1 inch. Assuming for the present that the dimensions of the lever and hanger and the location of point *T* have been correctly determined, we will examine the method of finding points *a* and *b*, and will then be able to show how all of the intermediate points of travel between these two may be located.

Limits of Valve Travel

In the full-gear-forward position — direction of rotation forward being clockwise and in the direction of the solid arrow near the eccentric circle—it is evident that the link block will reach its highest position when the center of the forward eccentric is at F_0, the highest point of the circle. When this occurs, the center of the reverse eccentric will be farther around the circle by an amount equal to angle *F O R*, Fig. 1, which locates point R_0. With F_0 as a center and a radius equal to the length of the eccentric rod, strike an arc *F*; and with R_0 as a center and the same radius, strike an arc *R*. Place the "R" point of the templet on the "R" arc, the "F" point on the "F" arc and slide the templet around until point *S* touches arc *C J*, Fig. 2. Reach through the slit in the templet with a sharp pencil and mark the point where the slit crosses line *A B*—this will be point *a*. The respective positions of the centers of the two eccentrics in the lowest position of travel are F_6 and R_6. With these points as centers, the arcs F_6 and R_6 are drawn and the link templet is fitted to them and to arc *C J*, thus locating point *b*. The *R'*, *F'* R'_6 and F'_6 points are the respective positions of the eccentrics used as centers for locating points *a* and *b* when the link is in full-gear-reverse position. The method is the same, and is clearly shown in the two positions of the dotted templet.

Intermediate Points of Valve Travel

Now for the intermediate points in the full-gear-forward position. To obtain these the eccentric circle is divided as shown in detail 2, Fig. 2. We have points F_0 and R_0 to start with, as before, and then for every 30 degrees around the circumference, we have corresponding positions of the two eccentrics: F_1 and R_1, F_2 and R_2, etc. A strip of paper, shown in detail 3, is now fastened to the drawing over line *A B*, and as each point is located, a corresponding mark is made on this paper with a sharp-pointed pencil

through the slit in the templet. On the downward stroke we have points 0, 1, 2, 3, 4, 5 and 6; and returning we locate points 7, 8, 9, 10 and 11. If the motion is perfect, we should expect to have in this position of the link a true symmetry of motion—as we had without any link—that is, point 7 coincides with point 5, 8 with 4, 9 with 3, etc. By examining detail 3, this is seen to be the case.

In detail 5, however, which is the record for the full-gear-reverse position, it is seen that these points do not coincide, and that the return motion of the valve is not quite the same as in its downward stroke. This discrepancy represents the error which is thrown upon the reverse motion of the valve by locating the link hanger at point S on the link arc. If it had been located in the middle of the link, the record of detail 5 would have been more perfect, but that of detail 3 would have been correspondingly less perfect. In detail 4 we have an illustration of what takes place when the link is thrown over 25 degrees toward dead center. It can be seen that the travel of the valve has been reduced and that the symmetry of the downward and return strokes of the valve has been greatly disturbed. This is as it should be, although we might not at first expect such a result, and the nature of these motions will be clearly shown when we have translated the records on these slips of paper into the form of curves.

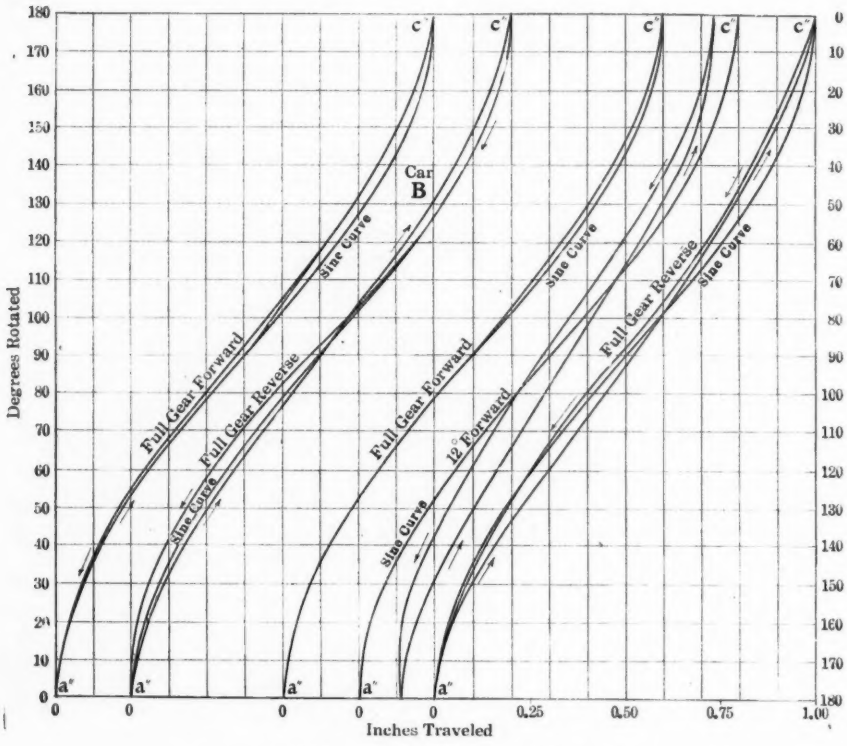


FIG. 3. ECCENTRIC-VALVE SYSTEM—LINK MOTION

Conditions Governing Design

Before we do this, however, let us look at the conditions governing the location of the link and the design of its mechanism. To start with we have the eccentrics, the eccentric rods, and the link. We know that these rods must be attached to the link, and we know that the link must be hung and connected in such a way that it will give the proper motion to the valve. But how are we going to do this?

First rotate the crank shaft until the centers F and R have reached their lowest symmetrical position to the center line $A\,B$—as they are shown in Fig. 7. Here angle $C''\,O\,F = C''\,O\,R$. If we start at a'' and follow the circumference of the eccentric circle in the direction of the forward rotation of the engine, we shall come upon the center of the forward eccentric, after having traversed an angle equal to 90 degrees plus the angle of advance. If we start at a'' and follow the circle in the reverse direction, we shall reach the center of the reverse eccentric after having traversed an equal angle. As the engine turns forward, the reverse eccentric leads the forward eccentric by an angle $F\,O\,R$, and as the engine runs backward, the forward eccentric leads the reverse eccentric by the same angle. This may, perhaps, be more clearly seen by a careful study of details 1 and 2 in Fig. 2. In detail 1 the reverse eccentric is the master eccentric, and in detail 2 the forward eccentric is the master eccentric. The master eccentric starts at the upper dead center of the circle and proceeds by steps of 30 degrees around the circle in the direction of the arrow. The other eccentric is shown in each corresponding position only for the purpose of furnishing a center for the arc to which the corresponding leg of the templet must be fitted.

Having turned the crank shaft to the position shown in Fig. 1, it is found that the forward eccentric is on the right hand side of the line $A\,B$. Then point S of the link must also appear on this side, and the eccentric rods can be connected as shown in Fig. 1. It will be noted that in this position the rods do not cross each other. This style of connection is called that of "open rods," and is the common method. Crossed rods are sometimes used, but the resulting motion on the valve is decidedly different. Their action is different, but is no more complex or difficult to understand than the action of the open-rod connection. The method which is being described is general in its application and can be employed with equal facility for either case.

We now have the link connected to the rods, and we also have a general idea that it must stand somewhere above the crank shaft in the vicinity of line $A\,B$, but we have no definite ideas as to its location. The next step is to assume the length of the link hanger $S\,M$. This had better be long, the longer the better within reasonable limits, and the length shown in Fig. 1 gives good results. The hanger is here shown a little longer than the link. Make it some even number of inches—there is no chance for hair splitting in its design, and its location is of far greater importance than its length. Having settled this question the next problem will be the location of the arc $D\,E$.

The point M, which is the full-gear-forward position of the lever end of the hanger, must first be determined. Experience has shown that it will lie on or near a line drawn perpendicular to $A\,B$ through point b. For the first approximation take point F_0 as a center, and with a radius equal to the length of the eccentric rod plus the radial distance on the link templet from point F to the link arc slit, strike an arc cutting line $A\,B$. Through this intersection draw a line perpendicular to $A\,B$ extending to the left. Measure off on this line from the point of intersection a distance slightly greater than the difference between the length of the hanger and the distance $F\,S$ on the link. This will be the first trial point M. With this point as a center and a radius equal to the length of the hanger, strike a trial arc $C\,J$. Now locate points a and b with the templet, as before explained. If the distance $a\,b$ is exactly 1 inch, a valve equal to the diameter of the eccentric circle $a''\,c''$, and the right end of the link arc slit has not been pulled to the left of line $A\,B$, then M is very near the correct position; but if $a\,b$ is less than 1 inch, there is something wrong, and point M must be moved to the right or left. A few trials will serve to locate M in this direction, and then a still greater refinement may be obtained by moving M up or down in a line parallel to $A\,B$. This looks

like a cut-and-try method, and so it is. There are so many different variables involved—the dimensions of the link, the length of the hanger, the throw of the eccentric, the length of the eccentric rods, the angle of advance, etc. — that no attempt has been made to work out a rule for the exact location of point M at the very first trial. In locating this point, two results must be attained: The extreme up-and-down travel of the link arc slit on line $A\,B$ must be exactly 1 inch, and the right end of the link arc slit must never move to the left of line $A\,B$. If it does, it will cut down the clearance between the end of the link slot and the link block. When these two conditions are fulfilled, there will be no need of further anxiety in regard to point M.

Points a and b have now been determined, and the location of M' will not be so difficult. It will be found a short distance to the left of $A\,B$, about on a line with point a. Arc $G\,I$ must be so located that the points a and b found by the link templet in the full-gear-reverse position, coincide exactly with the points found in the forward position. This locates the two points M and M' on the arc $D\,E$, and we know that in these two positions the center of the link block will be drawn up and down by the link over the same path $a\,b$.

In order to locate this arc exactly, we must either determine a third point or assume the radius $T\,M$. The writer's experience in link design has shown that $T\,M$ should be made one-half the length of the link hanger, and that the arc should be convex upward, that is, center T should be below and not above the arc $D\,E$. With M and M' as centers and a radius equal to half the length of the hanger $M\,S$, strike two arcs intersecting at point T. The length of the arm $T\,N$ may depend somewhat upon the reverse-lever mechanism, but it must be long enough to give a good leverage, and it is a poor plan to make it shorter than $T\,M$. The angle $M\,T\,N$ of the bell-crank lever must be such that the bisector of the angle $N\,T\,N'$ will be perpendicular to the rod connecting to N. This divides up the angle and makes the pull of the rod the most effective.

By noting detail 4, Fig. 2, it will be seen that the upper points 0-11 of the reduced valve motion are a certain distance below point a; and that the lower points 5-6 are the same distance above point b. Distance $a\,b$ represents the full valve travel of 1 inch, and the distance 0-6 represents the reduced valve travel when the link is hooked up 25 degrees forward. There can hardly be any question in regard to the way in which this difference should be divided. Half the difference should be taken from each end of the normal valve travel, thus making the reduced motion of the valve symmetrical about the central position. In order to accomplish this result, it has been found that the arm $T\,M$ must be one-half the length of the hanger, and that the arc $D\,E$ must be convex upward. This is not to be understood as a hard and fast rule, however, for the following reason:

After the records on the slips of paper have been translated into curves, and the valve diagram has been constructed, the designer may discover some reason that would make an unsymmetrical travel desirable. The lead on the crank end of the valve might be so great that a slight shifting of the valve travel would be a benefit. This can be accomplished by changing the length of the radius $T\,M$ and altering the position of point T. The arc must always pass through M and M', but a variation in its intermediate curvature will destroy the symmetry of the valve travel and shift the distance 0-6 up or down in respect to points a or b.

The reason for taking the records of the valve motion for different positions of the link on separate slips of paper is twofold. First, to preserve each record for future reference, and, second, to avoid confusion. If the records were super-

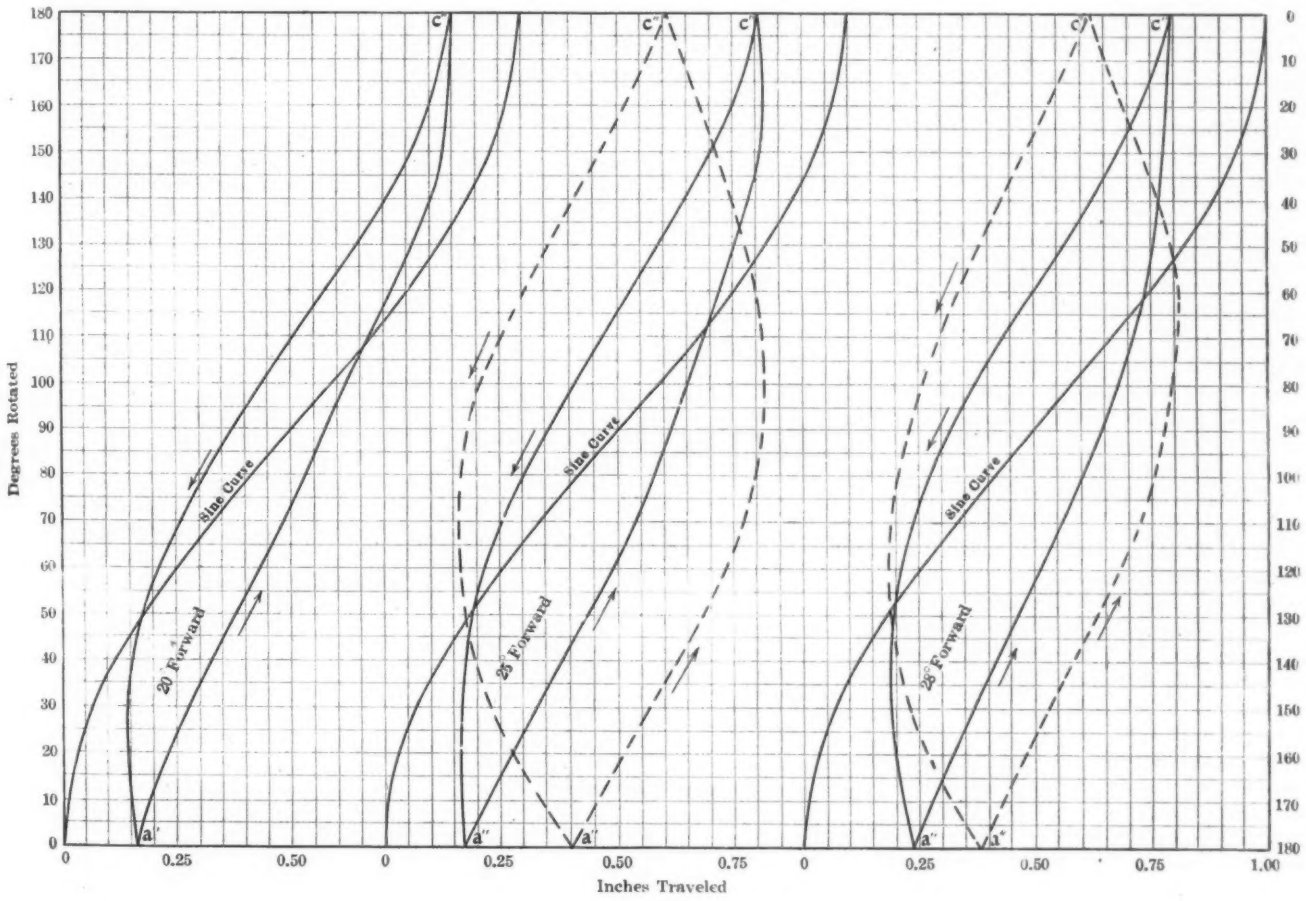


FIG. 4. ECCENTRIC VALVE SYSTEM—LINK MOTION

imposed upon one another on the line *A B* of the diagram, there would soon be hopeless confusion, chance of error, and the necessity of frequent erasure, which would destroy the records. Points *a* and *b* are clearly marked on the diagram, and, as soon as a new slip of paper is fastened in position, horizontal lines are drawn across it, with the T-square, through points *a* and *b*. This may be seen by inspecting details 3, 4 and 5, Fig. 2.

Plotting the Records

After the records are obtained they are plotted as curves between degrees rotated and inches traveled. A variety of curves have been shown in Figs. 3 and 4, and a study of these will tell more about the nature of the motion given to the valve by the link than can be gained in any other way. All of these curves, except the first two, marked "Car B" in Fig. 3, have been taken with the eccentrics at an angle of advance of 46 degrees, and a length of eccentric rods of 10 inches. The two "Car B" curves were taken from another type of engine, in which the angle of advance was 39 degrees and the length of the eccentric rods 7¼ inches. There was also some difference in the size of the two links, and in the length of the hangers, etc. The curves have been placed close together for ease of comparison, and the abscissa scales of the adjacent curves overlap. This should cause no confusion, as the sine curve, whose travel is always 1 inch, has been shown in each case. The second set of curves in Fig. 3 and all the curves in Fig. 4 have been taken from the same link mechanism and can therefore be compared with one another.

The first curve, marked "full gear forward," was taken from record 3, Fig. 2. It follows the sine curve very closely and the motion of the valve is symmetrical, that is, it travels up and down on the same path. The full-gear-forward curve for "Car B" resembles this curve in general direction, but the return of the valve is along a slightly different course than the downward stroke. The up-and-down paths are marked by arrows. The full-gear-reverse curves for both types of car exhibit considerable irregularity and illustrate the effect of connecting the link hanger to the forward end of the link. There is bound to be a certain amount of imperfection in the link motion due to the necessity of using rods and levers of finite dimensions, and it is far better to have all of this error appear where it will do the least harm.

In the second set the middle curve shows what the link begins to do to the valve motion as soon as point *M* moves in the direction of the dead center. The curves of the valve motion on its up-and-down strokes are now distinctly different, and the shortened travel of the valve is readily seen by comparison with the sine curve. This is 12 degrees forward. In Fig. 4 we have the curves for 20, 25 and 28 degrees forward, respectively. A glance at these shows what happens. The further the link is hooked up, the greater will be the distance between the up-and-down curves, and the shorter will be the travel of the valve, or the abscissa distance between points *a″* and *c″*.

How to Obtain Shorter Cutoff

Moving the link toward dead center produces a shorter cutoff, and we are now ready to learn how this is accomplished. Many people, if asked this question, would say that it was because of the reduced valve travel. If you were inclined to think deeply, this would leave you as much in the dark as ever. In Fig. 5 is a valve diagram from the full-gear-forward curve of Fig. 4. Fig. 5 has been worked out merely for the purpose of comparison with the diagram of Fig. 6, which tells the story of the reduced cutoff. The head-

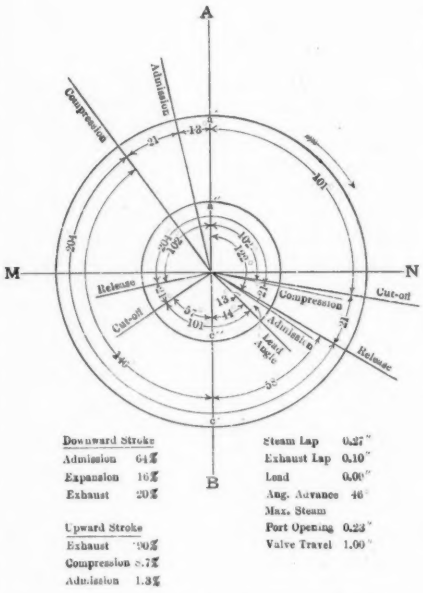


FIG. 5. HEAD-END DIAGRAM—LINK FULL GEAR FORWARD

end valve dimensions have already been determined in Fig. 5, and are: Steam lap, 0.27 inch; exhaust lap, negative, 0.10 inch; and lead, 0.09 inch, which amounts to 13 degrees angular lead in the piston-crank system, and corresponds to 1.3 per cent. of the stroke.

Now let us construct the diagram, Fig. 6, for the link in the position 25 degrees forward, middle curve of Fig. 4. The steam lap of the valve is 0.27 inch, which means that admission begins when the valve has moved down from its highest position an amount equal to

$$0.50 + 0.27 = 0.77$$

inch. Following up the 0.77-inch ordinate in Fig. 4, we find that it intersects the curve of the valve motion from *a″* to *c″* in a point corresponding to 135 degrees rotated from *a″* in the direction of the arrow in Fig. 6. The angle of advance being 46 degrees, we have admission taking place 1 degree before the dead-center position is reached, that is, the lead has now become less than it was before the link was hooked up. It is now known that cutoff will occur when the valve, on its return stroke, has once more reached a position 0.77 inch from the limit of upper travel.

Following the 0.77-inch ordinate until it intersects the return curve in Fig. 4, from *c″* to *a″*, we find that the valve is closed after a rotation of only 15 degrees beyond *c″*. This makes the total angular travel of admission, ignoring the lead angle, equal to

$$44 + 15 = 59$$

degrees; see Fig. 6. But 59 degrees in the piston-crank system is only equal to 25.3 per cent. cutoff. The cutoff produced by this same valve in the full-gear-forward position (see Fig. 5) is equal to 64 per cent. The amount of the reduction has been very great, and the reason is now plain and simple. The short cutoff is produced by the rapid lifting of the valve on the up stroke, due to the peculiar motion of the link. The apparent motion of the forward eccentric, which drives the valve in Fig. 6, is no longer symmetrical in regard to the center line *A B*. Coming down, the crank shaft must rotate the eccentric through 44 degrees between the beginning of admission and the point of maximum port opening, but it only requires 15 degrees rotation on the other side of the line *A B* to close this opening. The shorter cutoff is not entirely due then to the decreased valve travel, but to the quick return motion of the link mechanism. The decreased valve travel assists in shortening the cutoff, however, for as points *a″* and *c″* draw closer together on the abscissa scale, both up-and-down curves are cut at a higher point by the 0.77-inch ordinate, and the angular period of admission is decreased more and more.

Another very noticeable result is the rapid reduction in the size of the port opening. In Fig. 5 the port opening is 0.23 inch, in Fig. 6 it is only 0.05 inch; and, if the link was pushed over to the 28-degree forward position, the opening would be reduced to 0.02 inch. In this position the lead would have become negative, that is, the port would open, say, 10 degrees after the crank pin had passed dead center, and the entire diagram would have become distorted.

As dead-center position is approached, the character of the valve diagram suddenly changes from a reasonable distribution of the steam to a ridiculous inefficiency of valve motion, and the designer should beware of this condition.

Locating Point of Release

Continuing the diagram, we next locate the point of release. The exhaust lap is —0.10 inch, which means that the exhaust port will open when the valve has lifted

0.40 inch from its lowest position, and this will be somewhere on the 0.60-inch ordinate in Fig. 4. This ordinate intersects the return curve of the valve motion of 48 degrees around from c'', which is 33 degrees farther than the point of cutoff. For locating the beginning of compression, follow the curve of the valve from a'' to c'' until ordinate 0.60 inch is intersected at an angular distance of 85 degrees from a''. This gives 217 degrees for the period of exhaust and leaves 50 degrees for compression. The diagram may be studied out in detail without further explanation, and, as previously stated, the curves if carefully studied tell the whole story of the link motion.

Results of Hooking up the Link

A comparison of the data given in Figs. 5 and 6 illustrates the result of hooking up the link. Along with the reduced cutoff comes a lengthened period of expansion, a longer and differently distributed period of exhaust, a tremendous compression and a greatly restricted port opening, but not necessarily greater lead, as is sometimes supposed. In this case the lead is less, but under different conditions of valve dimensions or angular advance, it might possibly be greater. It all depends upon where the ordinate, which is equal to half the travel of the valve plus the steam lap, intersects the characteristic curves of the motion of the link in question. The statement that the lead increases as the link is hooked up is most certainly not one of general application. The crank-end diagram for the link motion will not be worked out, as it is very similar to the one in Fig. 6, except that there is a decided amount of lead, when the link is 25 degrees forward, partly owing to the shorter steam lap on the crank end of the valve and partly to the shape of the curve from c'' to a''. The lead actually increases in this case over its initial amount in the full-gear-forward position, and with the unbalanced parts of the vertical engine to be taken care of, it is better so, but if it should be desirable in some other design to change this condition, the remedy is to alter the radius of the arc DE, Fig. 2, until a curve of the desired shape is obtained.

A Peculiar Record

One of the most interesting applications of the curves to an analysis of the nature of the link motion yet remains to be shown. When the 25 degree-forward curve was plotted, it appeared to be getting too near dead center, and out of curiosity a peculiar record was made with the templet. The link was in the 25 degree-forward position, and for the solid curve in Fig. 4, detail 2 of Fig. 2 was used for the points or centers on the eccentric circle. To see if it would be possible for the engine to run backward in this position, a record was taken, using detail 1 for the centers just as though the curve for the full-gear-reverse position was being worked out. The result was the dotted curve shown in Fig. 4. This curve shows what the motion of the slide valve would be if the engine were turned over by hand, or otherwise, in the reverse direction, while the link was hooked up 25 degrees forward.

Let us see what would happen if this were tried. The steam lap of the valve is 0.27 inch, and the valve must be pulled down 0.77 inch before the steam port opens. Following the 0.77-inch ordinate up to its intersection with the dotted curve from a'' to c', we discover that the port will open when the reverse eccentric has rotated 70 degrees around from a''. But the angle of advance is 46 degrees, and

$$46 + 90 = 136$$

degrees;

$$136 - 70 = 66$$

degrees lead, which represents the tendency at this point to prevent the engine

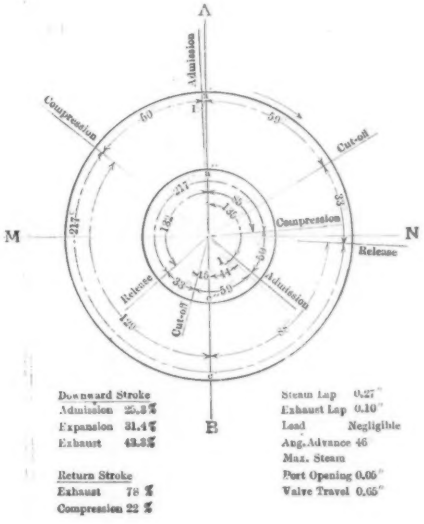


FIG. 6. HEAD-END DIAGRAM—LINK 25 DEGREES FORWARD

from running backward. In the 28 degree-forward position this angular lead has decreased to 51 degrees, which shows that the influence of the reverse eccentric is increasing as dead center is approached. It can readily be seen, by comparing the 25 degree and 28 degree position curves in Fig. 4, that as dead center is approached the area between the up-and-down parts of the solid curve, which represents the motion of the valve for the forward positions of the link, grows larger, while that between the parts of the dotted curve becomes smaller. Continuing the proposition, we have these two sets of curves becoming coincident at the dead center; after this the dotted curve will inclose the smaller area of the two as the link is thrown farther over, the engine will reverse its direction and conditions will gradually change until the reverse eccentric completely controls the situation.

To sum up, we may say that as the link is moved from either full-gear position toward dead center, an increase in lead does not necessarily occur until dead center is almost reached; and the engine cannot run backward until after the dead center has been passed, because of the enormous lead which is maintained by the reverse eccentric clear up to the dead center. At this point the forward and reverse leads are equal.

In conclusion, it may be said that it has not been the purpose of this article to take up the mechanical details of link-motion design. These may be obtained from many good textbooks. It has rather been the purpose to point out a method of exact design for use in the drafting room. A method of design which will take into consideration the action of disturbing elements that might otherwise be overlooked.

It has also been the intention to show just how the link acts, and how it accomplishes the result of producing a short cutoff. The curves are useful in showing just what imperfections exist in the action of a proposed mechanism for the piston-crank or eccentric-valve systems. The diagrams have the advantage of being exact, and of clearly showing the relation between the motion of the eccentric and that of the crank pin.

It may seem that a great deal of time will be needed to plot all the curves and figure out the diagrams, but it has been the writer's experience that the work goes along quite rapidly as soon as the method is understood, and where the design is completed, there is great satisfaction in the knowledge that everything has been taken into account.

Gas Power Section of the A. S. M. E.

The season of professional meetings of the American Society of Mechanical Engineers will be opened on Tuesday evening, October 13, by a meeting of the Gas Power Section in the Engineering Societies building, at 29 West Thirty-ninth street, New York. H. L. Doherty, chairman of the meetings committee of the section, will present a report for discussion outlining plans for future work, and there will also be a discussion of standards to be used in gas-power work.

Two papers will be read, one by E. A. Harvey on gas-producer plants, with data upon costs, performance, etc., and one by N. T. Harrington giving the results of tests to determine the loss of fuel weight in a freshly charged producer, due to increase of ash contents in the fuel bed. The first paper will be illustrated by lantern slides, showing actual plants and plans for the arrangement of apparatus.

Practical Letters from Practical Men

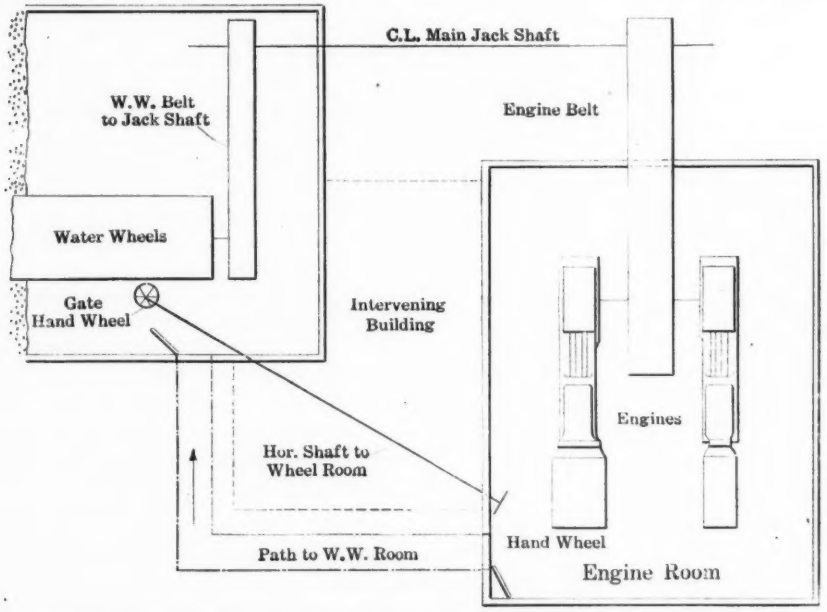
Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Remote Control of Water Wheel Gates

In many places where water wheels are run in connection with steam engines it is necessary to have some convenient means of shutting down in case of emergency, for frequently the engines and water wheels are some distance apart and there is no one stationed in the wheel room.

One of the simplest arrangements for accomplishing this purpose is shown in the accompanying sketch. It consists of a vertical shaft coupled to the original gate-wheel shaft and carried to the desired hight to bring it on a line with a convenient hight in the engine room. From here a horizontal shaft runs to the engine room and is coupled to the vertical shaft by a pair of miter gears. The horizontal shaft is held in place by suitable hangers, and on the engine-room end a large hand-wheel is placed. The shaft may be run in any direction with the aid of miter gears and, with very little care, can be made to always work easily in the bearings.



CONVENIENT ARRANGEMENT FOR EMERGENCY CONTROL OF WATER-WHEEL GATE

The cost of installing is slight, and by the use of the arrangement a great deal of inconvenience is overcome and a quick shutdown insured.

The sketch represents the arrangement as it is installed in a medium sized power plant, and has worked successfully for a number of years.

W. L. WHITMARSH.

Phenix, R. I.

Cleaning Water-tube Boilers

There is an article on page 93 in the July 21 issue that might lead one to believe it is a big job to clean a water-tube boiler of the Babcock & Wilcox type. If the work is systematized it is an easy matter to keep boilers of that type clean. The tubes are the most important part of the heating surface, and therefore should be kept free from scale. This can be done by using a good turbine cleaner. The drums, not being exposed to direct heat and being free from tubes, can be kept absolutely clean.

We have six 350-horsepower Babcock & Wilcox boilers, four of which are in service while two are out for cleaning. The boilers are cleaned each month; that is, each is in service a month between cleanings. After a boiler is cut off from the header the shell, tubes and headers are blown clean from soot. The boiler is then allowed to stand twenty-four hours. The furnace, ashpit, and combustion chamber are then cleaned.

The boiler is drained, manholes opened, and the front caps removed. While the boiler is cooling, the bolts and inside plates are cleaned. The bolts are put in kerosene and soak until everything is ready to cap up. The drums are next scraped and washed; the pipe to the water column being cleaned and washed at the same time. The tubes are next cleaned with a good turbine cleaner, which gets practically all the scale out of the tubes and back headers. The turbine is run through the circulating tubes every third cleaning.

The caps and nuts are polished by rubbing with a rotary motion of No. 2 sandpaper lying on a flat surface. The header faces are cleaned by means of strips of sandpaper tacked to a piece of board 4 inches wide by about 6 inches long. The bolts are taken from the oil, and the threads cleaned with a wire brush. In heading or capping up the bolt and plate are slipped in place and the cap seats given a light coat of joint grease when they are put on and nut face coated with grease and drawn up by hand. As the nut draws, the cap should be rotated to grind any grit that might get between faces.

After all caps are replaced and the manheads closed, muddrums scraped, washed and closed, the blowoff valves are taken apart and looked over for signs of leaks. If found O. K., the stems are packed and the valve put back in place.

The glands of the feed valves and water glasses are packed, and the openings to the water column from the glass inspected. The boiler is then pumped up to 100 pounds pressure and examined for leaks.

Stop valves are packed about once a year. Blowoff valves and nipples to the muddrum are sounded with a hammer at each cleaning.

The time required for the above job is as follows:

	Hours.
Cleaning furnace, ashpit and combustion chamber	5
Uncapping and cleaning bolts and plates	5
Scraping drums and washing out	4
Turbining tubes	5
Polishing caps, nuts and header faces	8
Capping up boiler	10
Overhauling fittings, etc	4
Total time	41

Our boilers are pushed beyond their capacity about ten hours out of the twenty-four. We have removed eight tubes so far this year. Our average loss for the past six years has been twenty tubes a year.

B. C. HONX.

California, O.

Breaking Strain of Plow-steel Rope

In the July 28 issue of POWER AND THE ENGINEER, on page 170, R. G. asks for a breaking strain of a plow-steel rope and also the rule for obtaining the same. The formula I use is as follows:

Square the diameter in eighths and multiply by the constant 500 for iron rope, 750 for steel, 1150 for crucible steel and 1400 for plow steel.

Example: A 1-inch iron rope: diameter squared in eighths, or $8 \times 8 = 64$; $64 \times 500 = 32{,}000$; $32{,}000 \div 2000 = 16$ tons breaking strain. One-fifth of this is the safe working load. It is seldom we see a rope of odd sixteenths in diameter, and so with more than 5/8 and less than 3/4 or 6/8 we have to change the numerator to a decimal, so it equals 5.5 squared = 30.25; $30.25 \times 1400 = 42{,}350$; $42{,}350 \div 2000 = 21$ 1/6 tons, nearly. The safe working load would be 1/5 of 21 1/6 tons, or 4.23 tons.

JAMES C. STEWART.

South Wilmington, Ill.

Blaming the Engineer or Fireman

I read with regret of the York, Penn., boiler explosion. In case of an explosion or accident to a boiler, the first thing, generally, is to blame the fireman or engineer, and I think this is wrong.

I am employed by a company which installed a live- and exhaust-steam heating system last spring, using the returns again in the boilers. I objected to this on account of the oil, with no satisfaction but an "I guess not," and was told to go ahead and connect up the piping as ordered. The result was in about sixty days the boiler bagged and had to be repaired at a cost of $100.

Of course, I was blamed at first, but after calling in the boilermaker and the insurance company inspector, the firm was convinced the trouble was due to oil. I had also been ordered to use crude oil in the boilers once or twice a week, which was also against my better judgment.

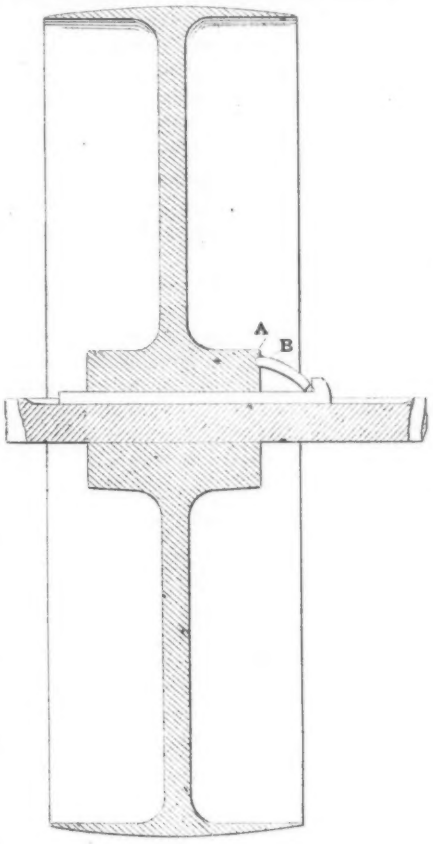
I also have under my management a boiler of the overhanging-front type which was walled in and a full-flush front used, with the result that the bottom of the smoke box has been burned away. I have repaired this with brick so as to prohibit the flames from coming in contact, causing the rivet heads to be burned badly. I have reported it to the firm, also to the inspector, and have not met with much encouragement, so if this boiler explodes or kills a few men, I suppose people would say they should have had a responsible fireman, one that ought to look for all those defects. It is a good way for corporations to get out of trouble if they can put the blame on their men.

ROY STAHL.

Rising Sun, O.

Drawing a Tight Key

The method for drawing tight keys shown in the July 28 issue is good, but if the pieces of steel used are slightly bent and the pounding done at the point marked *B*, an enormous pressure can be brought to bear against the key head. Cut a slight notch at *A* to keep the end of the



DRAWING A TIGHT KEY

steel strip from slipping and you may rest assured something will come.

GEORGE R. WILLIAMS.

Findlay, O.

Belt Lacing

I have read with interest the discussion on "Wire *vs.* Rawhide Lacing," and would like to tell of my experience. In my younger days I was very familiar with rawhide lacing and always had good success on belts of from 1½ to 14 inches in width, but a couple of years ago I installed a fan for ventilation which was run by a motor, by means of a 4-inch belt, running from a 3-inch pulley on the motor to an 8-inch pulley on the fan. The speed of the motor was 1800 revolutions per minute. The belt was at first laced with annealed-iron wire, the first I had ever seen, and it was said that it would last forever, but in ten days it broke. I laced it again very carefully, and it did no better. Then I tried copper, which was worse. Fourteen months ago I tried the old-fashioned rawhide and it is still doing good service, running every working day. I have not looked at it for six months, and I have concluded that rawhide is good enough for me.

M. S. PIXLEY.

Springfield, Mass.

Neglected Boilers and Owners' Responsibility

Nothing has appeared in the columns of POWER AND THE ENGINEER for some time that has been so much to the point, so straight from the shoulder and true, as the editorial, "A Needless Loss of Life," in the August 25 number. I do not know which one of the editors wrote that editorial, but I hope that every official of the Susquehanna Iron and Steel Company will read it and know that one engineering paper on this continent is not afraid to tell them to their faces that they are *guilty*, and that the explosion was not "unaccountable."

I have thought a great deal over the question of an owner's relation to his boiler, and without any joking whatever, I have come to the conclusion that his proper place is on top of it. Some may feel inclined to laugh at that, but if I had the power I would make it the law that the offices of the general manager, president and superintendent be situated directly above the boiler room in every concern where boilers are used.

Be it said to the credit of the officials of a great many companies that they want their plants *right*, but there are too many others whose hides are a "heap sight" more tender than their consciences, and if they were compelled to keep their skins for several hours per day in close proximity to their boilers they would naturally keep their boilers right. I do not know whether the $10,000 to $15,000 in Mr. Rogers' article includes the loss to the company by interrupted business, or not, but from a purely money point of view, I would like to ask how much the company in question has *saved* by their false economy? How many brand new boilers would $15,000 install, to say nothing of the lives that would have been spared had the money been thus expended?

I am personally acquainted with a young fireman who found employment under such employers. The battery of three boilers were in a very questionable condition and were in charge of a careless, fearless engineer, and as the fireman's duties occasionally kept him with the boilers all night, when no one else was about, he decided that he would run no risks, but would test the boilers for himself, the plant being in an out-of-the-way place. Accordingly, one night, he shifted the balls on the three safety valves out about one-third farther on the levers. This raised the blowing-off point from about 120 pounds to about 160 pounds. He then

raised steam to 120 pounds and left good heavy fires under each boiler while he went about one-fourth of a mile away into the woods and waited for either the valves to blow off or the boilers to blow up. Fortunately, one of the valves blew off and in an hour he went back, feeling more content, and put everything back where he found it. He had still plenty of water in his glasses and from that day to this the company has not had a report of that boiler test. One does not know whether to commend or condemn the lad; but I know this, that my head would lie much easier on my pillow with three bursted boilers to my credit than it would with ten dead men to answer for.

R. MANLY ORR.

Brantford, Ont., Can.

Preventing Flywheel Explosions

The recent editorial, "Preventing Flywheel Explosions," is timely and to the point. Agitation along these lines is absolutely necessary if the frequent disasters of this character are to be prevented.

The Corliss engine is particularly susceptible to this form of accident, largely because the automatic knock-off safety device with which these engines are ordinarily equipped is liable to be inoperative. This may be due to neglect of the engineer in charge, or it may be that the device interferes with the actual operation of the engine, and therefore has to be discarded. There are instances where the engine will stop under heavy load or low water pressure—on account of the low position taken by the governor—when the automatic stop is properly adjusted. More boilers or a larger engine is then the only solution of the trouble.

The large, thin-rim band wheels, made in halves, are another source of danger to Corliss engines. These wheels usually are operated at low factors of safety, and a small increase in speed will frequently wreck them. These wheels at least should be made with double arms along the split, so that the rim lugs are directly tied back to the hub.

A source of danger to throttling engines, not generally realized, is the passage of pieces of rubber packing used for gaskets in flanged pipe joints through the governor, blocking open the governor valve when heavy loads are thrown off. I have known of one wreck caused by this temporary stoppage of the valve by pieces of packing. These were found in small bits in the steam pipe and steam chest on either side of the governor valve.

Steam pipes should be blown out at intervals to clear them of débris that may have collected in them.

J. B. STANWOOD.

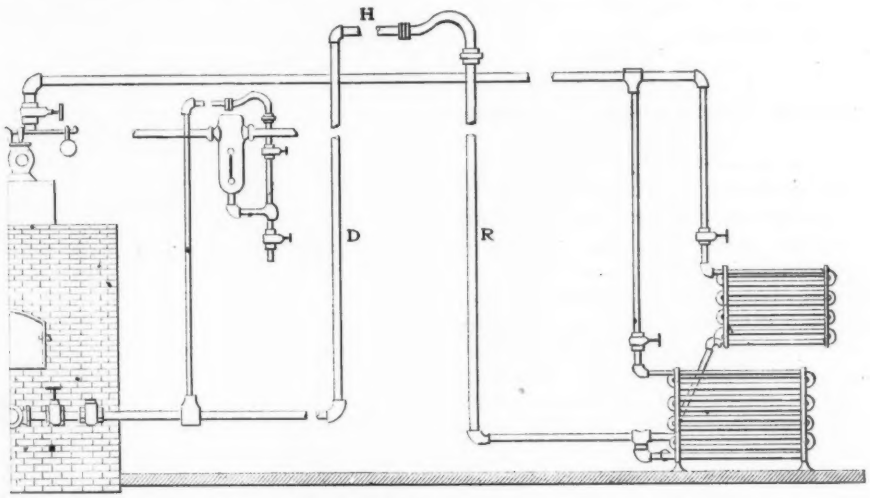
Cincinnati, O.

Steam Loop Trouble

While the steam loop is a very simple device—only a return pipe leading from the source of condensation to the boiler, with nothing complicated about it—yet I am not surprised to hear of them giving trouble to anyone, for in my experience with some half dozen or more I have frequently fared the same way.

In the first place, Mr. Beard is having his trouble with one of the most troublesome sort of steam loops, viz., one in which his radiators, or heaters, are set below the water level of his boiler. This condition troubles engineers more than any other and requires more accurate calculations and proportions of parts when installing.

Now, the riser *R* (see illustration) does not contain simply water alone, but a mixture of water and steam. As this mixture condenses, the process of mixing is constantly taking place in the horizontal pipe *H*. This mixing process at *H* has a tendency to produce a vacuum at that point, and would do so but for the fact that the steam and water from the riser are constantly taking the place of the condensing steam. Now, the steam and water spray, having passed the gooseneck in the horizontal pipe, is entrapped, hence it cannot return, but must constantly work on toward the boiler.



ILLUSTRATING J. L. BRADSHAW'S COMMENTS ON THE STEAM-LOOP TROUBLE

In order to properly proportion a steam loop we must first ascertain the specific gravity of the mixture in the riser, the difference between boiler and separator pressure, and also the working pressure under which the system is to operate; otherwise we would not be able to determine the weight of the water at the first ascertained pressure and temperature.

One cubic foot of water at 60 degrees Fahrenheit and at a pressure of one atmosphere, weighs 62.3 pounds. Then a column of water 1 inch square and weighing 1 pound will measure 144 ÷ 62.3, or 2.311 feet in hight.

Let us assume that in Mr. Beard's case we have a difference of 6 pounds pressure between the top and bottom of the riser, and that the lowest point in his returns is 8 feet below the water level in the boiler. Then with steam pressure at 90 pounds, temperature of the water 331 degrees and the weight of a cubic foot 56 pounds, the hight of a column of water 1 inch square sustained becomes 144 ÷ 56 pounds = 2.571 feet for each pound weight. Taking the difference of 6 pounds in pressure assumed in this case, and the loop full of steam only, the water will rise in the drop leg *D* a distance equal to 6 × 2.571 or 15.426 feet, to balance the difference in pressure. Adding this hight to the required lift, it is seen that the top of the water column should stand 15.426 + 8 = 23.426 feet above the bottom of the riser for the system to be in equilibrium.

As previously stated, the riser *R* contains a mixture of steam and water, and let us take the specific gravity as, say, one-fourth that of water, assuming three-fourths of the volume to be steam. Then, by reason of this extra weight, we must lengthen the pipe accordingly. This will be 23.426 ÷ 3 = 7.808 +. Adding, we have 23.426 + 7.808 = 31.234, total hight of the riser. Subtracting the 8-foot lift, leaves us 23.234 feet for the hight of the drop leg above the water level in the boiler. So we see that Mr. Beard is about 7.234 feet short in his drop leg to secure the most satisfactory working conditions.

If his main steam pipe is not over 4 inches in diameter, the 1-inch riser he has will be sufficient, but for pipes larger than 4 inches, say, 5 inches to 8 inches, the riser should be not less than 1¼ inches. It is much easier to get the piping too small than too large, and in the former case trouble is certain.

Any presence of air in the system will also prove to be a source of constant trouble, and not infrequently a good cause of complete failure. A small air-cock

should be placed on the highest point of the goose-neck, and invariably opened before undertaking to start the loop. It would also be well to open this cock frequently during the day if the loop is kept in continuous operation.

Always have drain valves to both separator and riser, and open the same before starting up, at the same time bearing in mind that the stop valve on the lower end of the drop pipe leading to the boiler must not be opened until the system is thoroughly drained.

If Mr. Beard will carefully look to these latter suggestions he may be able to overcome his difficulty without increasing the hight of his drop leg, but I hardly think he will ever be able to get the best results without first changing his piping.

J. L. BRADSHAW.

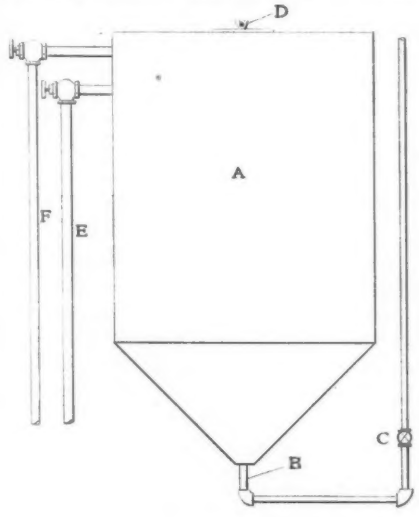
Memphis, Tenn.

Boiler Compound Feeder

The accompanying sketch is a boiler-compound feeder, designed by myself, and as there is no patent right on it, any engineer may build one and use it.

Referring to the sketch, *A* is a tank to mix and hold the liquid, *B* is a ¼-inch steam pipe from the boiler, *C* is a stop cock to regulate the steam supply, *D* is a 3-inch plug to open and close the tank, *E* is a ⅜-inch pipe to convey the mixture to the suction pipe of feed pump, *F* is a pipe to regulate the pressure between *A* and a return receiver tank from which the feed pump gets its supply.

In order to start the feeder, pour about 5 gallons of water into the tank *A*, which



A BOILER COMPOUND FEEDER

holds about 10 gallons of water. Then put the amount of compound it is intended to feed per day into the water, close the tank by screwing in the 3-inch plug, and open the stop cock *C* just enough to bring the water in the tank to a very slow boil. Then open the angle valve in the pipe *E* and the feeder is ready to operate. The pipe *F* is not necessary when pumping from an open tank.

It will be found when opening the tank *A* after, say, twenty-four hours' run, that there is just about as much water in the tank as there was the previous day, but it is clear water, the compound has all gone through pipe *E* in a diluted form, and all one has to do is to put in another supply of compound and close the tank up again.

The steam entering the tank through the pipe *B* serves a double purpose, i.e., to mix the compound with the water, and to supply all necessary water in the form of condensed steam, and the faster steam is admitted, the faster the feeder will feed, although it is advisable to feed as slowly as possible to get the best results.

The feeder should always be higher than the water supply, so as to feed by gravity. This feeder will feed any compound.

F. B. FIEDLER.

Chicago, Ill.

Repairing Leaky Flues

In reading J. L. Bradshaw's criticism of the article, "Scale in Boilers," and seeing that he was "amused to say the least," I was led to look up the article in the May 12 number, and where, instead of saying, "If you find the flue sheet worn out and the flues weak from constant expanding, get some 'Smooth-On' cement and apply according to directions and your troubles will be over," I should have added "until more extensive repairs can be made."

I remember a short time ago a plant having two 500-horsepower and one 250-horsepower boilers. The load could not be carried by any two boilers only from midnight Saturday to 7 a.m. Monday. The repairs, washing out, etc., were done on one boiler. When the oldest 500-horsepower boiler got so that the tubes would not hold and two cracks showed up in the flue sheet a new boiler was wired for and in the meantime "Smooth-On" was brought into play and the boiler carried its load with dry tubes until the new boiler was installed, when new tubes were put in and the cracks in the tube sheet were plugged.

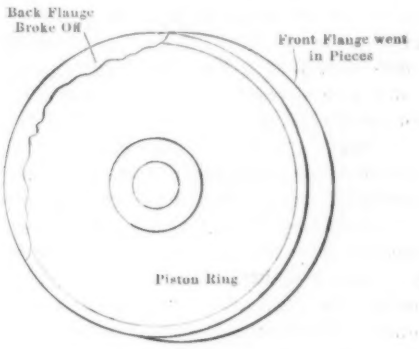
Mr. Bradshaw says that the best thing to do is to have a new sheet and flues put in or consign the boiler to the junk pile, both of which were impossible in this case, unless the plant had been shut down, and I don't think many engineers like the idea of shutting down when it is up to them to keep things going. I mention this because there might possibly be another plant in the world that has not additional boilers installed when the unexpected happens.

P. G. JONES.

Lincoln, Neb.

A Piston Accident

Recently, a piston collapsed as an engine was being turned slowly, just before getting it up to speed. The drips were



WHERE AND HOW PISTON BROKE

wide open at the time. The illustration shows the broken piston. What caused it?

WILLIAM J. HACKETT.

Brooklyn, N. Y.

Knock in Valve Gear

Referring to the request of William Ingram for information in the June 23 issue, page 994, in reference to knocks in the valve gear of an Atlas automatic engine, I would say that I have handled several of these engines and have had this same trouble. It is usually due to lost motion in the eccentric, or rather between the eccentric and straps, or in the pins that serve as fulcrums for the weight levers and the links that connect them with the eccentric. Lost motion in any of these parts will cause knocking, and I have found in some cases that the cause was due to all of them.

If it is the eccentric and straps, the remedy is, of course, to close them up a little, disconnecting the eccentric rod from the eccentric crosshead and turning the eccentric straps over on the eccentric to determine when the adjustment is right, then connect up again. If it is in the pins, the remedy is to have new ones, or to bush them. I have many times done this latter with success, and kept the engine running very nicely by attending to them as occasion demanded, as the bearings often need renewing. Persistence and watchfulness will enable an engineer to get along very nicely in this way, and the pleasure of having a nice running engine well repays the ambitious man for the effort.

A pound or knock in this part of an engine is caused by lost motion or a dry valve, and the way to get rid of it is to run down the cause and remove it. Oil costs less than engines, so I always aim to use enough.

WILLIAM WESTERFIELD.

Lincoln, Neb.

Closing Pop Safety Valves

At the bottom of page 193 of the August 4 edition of POWER AND THE ENGINEER is a small "filler" paragraph which advises the reader that "Some pop safety valves refuse to shut off when the pressure goes down," and "A chain to close, as well as one to open, such a safety valve is a necessity." This, in my opinion, is a very unsound bit of information.

A chain to close a pop safety valve would not be tolerated a moment by any intelligent engineer, and certainly would not be allowed by any reputable boiler inspector. How simple a thing it would be for such a chain to become caught accidentally on some projection, or for an ignorant attendant to hook it or weigh it down so the valve could not open wide or at the proper pressure. What are lock-up pop safety valves for but to prevent such actions and to make it difficult to tamper with the valve setting? If there is any device about a boiler which above all others should always be in first class operating condition, it is the safety valve.

In the case described, the necessity is not to provide the valve with a chain to close it, but to see that it is put in proper working order. It should be taken apart, carefully cleaned, and if necessary, repaired, so that the disk will lift and seat freely and properly without chattering.

It sometimes happens that safety valves do not act properly, due to being installed incorrectly. They are occasionally mounted, sometimes through necessity and often through ignorance, at the end of a vertical pipe of considerable length, or to an elbow or tee fitting attached to a horizontal pipe. Valves mounted in this way generally give a great deal of trouble by chattering and failing to close properly. This trouble occurs when the supply pipe, to which the valve is attached, is not large enough to keep the steam supply below the valve up to the full boiler pressure. In such cases when the valve starts to blow there is a very rapid rise and fall of pressure below the seat, which causes the disk to lift and close with sufficient rapidity to hammer the valve to pieces if the trouble is not speedily remedied.

I remember a troublesome case where two 3½-inch valves were mounted on a Y-fitting having a 5-inch inlet, which in turn was connected by an elbow to a horizontal pipe projecting about 2 feet from the side of a vertical boiler. When one of these valves blew off (one was set about 5 pounds below the other) the chattering was something terrific. All sorts of remedies were proposed and tried without results. The pipe could not be altered without great expense, and as it was evident that the valves were not getting a sufficient quantity of steam, the only remedy left was to reduce the size of the valves. Three-inch valves were therefore substituted for the 3½-inch, after which no further trouble was experienced.

Whenever it is possible to do so, pop safety valves should always be attached directly to the boiler. If an intervening pipe is necessary, it should be several sizes larger than the valve, and as short as possible. Elbows or tees should not be used unless the pipe connecting them to the boiler is made extremely short, and both fittings and pipe should be at least two sizes larger than the valve.

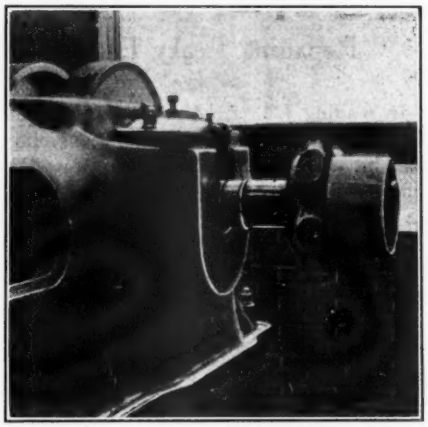
M. EVEREST.

Cincinnati, O.

Peculiar Accident to Engine

I am inclosing photographs of an 11x19x14-inch tandem-compound engine, direct-connected to a generator, that burst its governor wheel last December.

Nothing wrong was noticed with the engine until it suddenly started to race, and before the attendants could reach the throttle the 6-foot governor wheel burst, parts of it going through the roof, others



SHOWING FRAGMENT OF HUB LEFT ON SHAFT OF ENGINE

through the concrete floor, about 1 foot thick, and others through the dividing wall into the boiler room. Parts of spokes weighing over 100 pounds were found 500 feet away. The engine continued to run at an excessively high speed until the engineer on duty could shut the stop valves over the boilers. Nobody was injured, which is remarkable considering the number of men on duty and in immediate proximity to the engine, and the amount of wreckage blown around.

The generator escaped with a badly burned brush-holder arm and a blackened commutator. The governor wheel and entire high-pressure valve gear were demolished, the crank counterbalances were cracked half way around, the cover to the crank pit was broken and a bolt hole in the low-pressure eccentric sheave, where the throw of the eccentric is varied, sheared through. All the low-pressure valve gear was left intact, which was secondarily the cause of the bursting of the wheel. The primary cause of the accident was the breaking of the high-pressure valve stem near the stuffing-box gland. This threw the high-pressure valve far enough ahead in the steam chest to uncover the steam port and the exhaust port into the receiver, thus making a direct path for steam into the low-pressure cylinder. This cylinder was not controlled by the governor, neither had the receiver a pop valve on it.

The wreck was immediately cleared away and a cast-iron wheel about 4 feet in diameter, with an 8-inch face, and a hub that would bore out to fit the shaft, was found in the scrap pile and fitted to the shaft. The governor on our condenser was taken off, and put into the steam pipe above the throttle on the engine and a belt run from shaft to governor. The high-pressure valve was taken out and the steam-chest cover replaced, cracked counterbalances were repaired by drawing cracks together with two 1¼-inch bolts. Steam was turned into the engine at 10 p.m. that evening and the whole lighting load put on the low-pressure cylinder. When a new wheel arrived it was put on and all adjustments made in some eight hours, the total interruption to lighting service being but four hours on the day of the accident. The engine runs as well as it ever did and shows no sign of ever having been wrecked. This engine was exhibited at the Buffalo exposition.

The cause of the breaking of the valve stem is unknown; the valve was well oiled and working perfectly free and the port edges showed no evidence of anything trying to pass through by the valve. This valve stem has no link between rocker arm and valve yoke and it may have been that continual springing of the stem crystallized the metal at the stuffing box.

G. L. FALES.

Copperhill, Tenn.

Does Not Fear for Mother Earth

In the July 7 number of POWER AND THE ENGINEER, W. D. Ranney fears for Mother Earth in the present struggle of man to possess her natural resources. His chief concern is with the astronomical aspect of the struggle, as to the effect on the buoyancy of the earth.

From an astronomical point of view, which we may hypothetically assume as a spot in the heavenly sphere some few light-years distant from us, man and the earth are one. Also the gaseous coating, about 50 miles thick, surrounding the planet, is an integral part of the same; hence, if man wrests the resources from the bosom of the earth and, converting them into products of combustion, dissipates them in the atmosphere, they still remain part and parcel of the selfsame orb. True, they have shifted their position relatively to the

center of the earth, but their specific gravity, compared with the average specific gravity of the earth, which is 5.67, is so small that this displacement would hardly affect the center of gravity of the earth. And the center of gravity is the spot upon which the attractive forces of all the heavenly bodies act.

As for the buoyancy, which is but another name for specific gravity, it always will remain the same, unless some tremendous disturbance causes the earth to discharge into space a portion of itself, or a shower of meteors adds to its mass.

J. J. O'Brien.

Buffalo, N. Y.

What Caused the Rotor to Shift

On page 109 of the July 21 number, A. V. Youens makes further comments on the above question in reply to my communication published on page 828 of the May 26 number. Mr. Youens says he is not familiar with the construction of the type of rotor I described, and proceeds to give a complete and interesting description of a type built by a different company from the one that is building the machine I described.

While it would be interesting to know the construction of the particular rotor originally mentioned by A. K. S., the actual design or construction of the rotor does not materially affect the theory as to what caused it to move along the shaft.

The theory advanced by Mr. Youens that the rotor revolved at a sufficient speed to expand it away from the shaft, even if it could be accepted, would not account for the rotor moving lengthwise along the shaft. He also omits to say what the flywheel would be doing while the rotor was being stretched.

It would be well, perhaps, in order to prevent misunderstanding, to point out that the name rotor, as given to the particular piece of apparatus under discussion, is not strictly correct. It is, properly speaking, a revolving field. The name rotor was originally given to the revolving portion of an induction motor. The revolving field of an engine-driven alternator would, of course, be on the same shaft as the flywheel. To take a particular case, a 500-kilowatt alternator has a revolving field 9 feet in diameter and a flywheel 12 feet in diameter. The revolving field is built of steel and cast iron and is of much stronger construction than the flywheel, as is natural, having to transmit the full power of the engine. It is easy to see without going into figures, that if sufficient speed were developed to expand the revolving field enough to loosen it on the shaft, the flywheel would go to pieces.

As to the question, "what caused the rotor to shift?" leaving out the effect of a badly fitting bore on the shaft, it is evident that some force must come on the rotor whose resultant tendency is to move it sidewise. Imagine a disk keyed to a shaft and revolved at a certain speed; pressure is brought to bear sidewise on one edge of the periphery of the disk while revolving, and the tendency of the disk is to creep along the shaft in the direction in which the pressure is applied. It would take much less pressure to make the disk creep in this manner than would be necessary to push the disk along the shaft bodily. This was the action I had in mind when I suggested that the cause of the rotor shifting was due to the stationary field being out of line with the rotor; that is, the *axes* were not parallel, or coincident. It would not be necessary to have the stationary field 3 inches out of alinement to produce unequal pull on opposite sides of the periphery of the rotor, nor would it be necessary to have it that much out of alinement to move it 3 inches along the shaft.

Since writing on this subject, two cases have come under my notice, of heavy flywheels moving along their shafts, and although these cases are not exactly parallel with the case under discussion, they bear out my theory in some degree. The two cases were identical, the engines being single side-crank with outboard bearing, and flywheel mounted between; there was no generator. Both flywheels moved along the shaft until they rubbed the sides of the wheel pit and even then did not stop creeping along the shaft; but continued until the pressure on the sides of the pit made it compulsory to shut down the engines. The cause of these wheels shifting was the same in both cases, and was simply due to allowing one of the main bearings to become slack, giving a side wobble to the flywheel. The wheels would not move along the shaft as long as the main bearings were kept tight.

I am unable to say whether the flywheels fitted the shaft or not, but I could not put a 0.002-inch feeler in at any part of the bore between the wheel and shaft.

Frank Sawford.

Sydney, N. S.

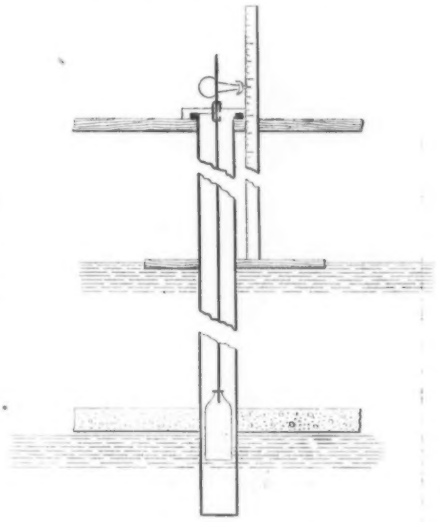
Head and Tail Water Gage

In the August 5 number a head- and tail-water gage is described, which, while giving approximate results in summer, or in a warm climate, it has too many pulleys and weights to be very accurate, and the water could vary several inches in hight before it would show on the gage, due to friction in the pulleys, nor would the gage be accurate at all stages of the water, for if it was set correct at high head it would not be correct at low head, due to a different amount of chain that would run over on the weight side, thus adding unequal amounts to the weights.

I also take it that the float is in the wheel pit, in which case you would not get the true hight over the crest due to the fall in the head race when the wheels are running.

As a substitute I offer the following, which in my opinion is a much better arrangement, as it is all inside and in winter or summer the results would be alike.

This device consists of a 12-inch pipe extending from the main floor down through the wheel-pit floor, and, being cemented in this floor and open at the bottom, will communicate with the tail race only; thus a float, in this case a glass bottle, placed in this pipe will float at the hight of the water below the dam, plus the back pressure (see illustration). This float carries a pointer only, although it could have a scale also. Another float made of wood and built around the pipe, carries a board laid off in feet and inches; this also might have a pointer attached to the floor which would give the hight over the crest except for the following reasons: It is not advisable to try to get head- and



S. E. SHAFF'S HEAD- AND TAIL-WATER GAGE

tail-race readings off of this gage, as the drop in the head race will vary with the load; the tail race also varies, due to the back pressure under the wheel-pit floor, and while we have ample room for the water to leave the wheels, this back pressure or tail-race fluctuation is considerable, so that the gage only indicates the actual or effective head at the wheels, which, after all, is just what we want to know.

In order to ascertain the flow over the crest of the dam I have placed a similar gage about 50 feet above the dam where it will always show the true amount of water over the crest regardless of the fall in head races. In this case, the pipe extends about 4 feet below the crest and 6 feet above. As this gage is out where it would freeze, we fill the pipe with oil to a little below the freezing line, thus making the gage available in winter as well as summer.

S. E. Shaff.

Iowa City, Iowa.

The Lighting of Underground Engine Rooms

The development of the show engine room, with its enameled-brick walls, artificial lighting and attractively arranged power units, has awakened a natural interest in the improvement of conditions which have hitherto been considered hopeless. Whitewash and daylight will work marvels in any place. In city plants in particular it is all too often considered that lighting without artificial means is an impossibility. But as a rule such engine rooms are more or less accessible to the transmission of daylight, if proper arrangements are provided. The refracting prism has in many cases solved the difficulty by throwing the light far into hitherto dark and dirty corners. So also has the sidewalk-vault light, with its numerous lenses.

The effect of such methods is well shown by the accompanying illustration, Fig. 1, of an engine room situated beneath the sidewalk. The room is not only light—it is fairly brilliant. The sidewalk construction, which was the work of the Aberthaw Construction Company, of Boston, Mass., consists of a series of circular lenses embedded in portland cement. The form of the lens is shown in Fig. 2; the top is flat, the under side is cupped to refract the light and the circumference is ribbed to insure a joint with the cement. Twisted reinforcing rods are run between the lenses to give stability to the entire structure. This design, which has been extensively installed throughout New England, provides the most essential features in such a sidewalk, namely, the opportunity to prevent leakage. But years of trial have shown that good workmanship born of experience is just as essential as the design in securing a result that is waterproof.

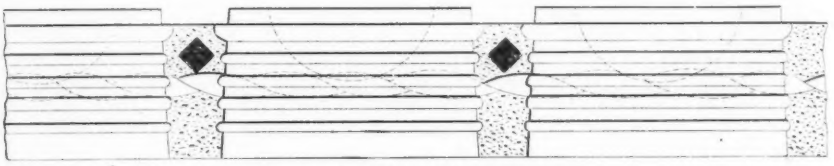


FIG. 2. SPECIAL DESIGN OF LENS

Duplex Steam Pump Troubles

By Charles E. Bascom

There is no accessory about the steam plant that receives the neglect that is bestowed upon the steam pump. You find it in some dark corner of the plant or in some pit half submerged in dirt and water. Sometimes it is oiled, and sometimes it is not—more often not. The only phenomenon about the pump is that it runs at all under the conditions in which it is placed. Even some of the builders seem to have a grudge against the pump, sending out any number of them with cast-iron rocker shafts and with stuffing boxes that will only hold 2-inch rings of packing. This is too often the case with the duplex pump.

If the cast-iron rocker shaft is not oiled properly, it will very soon wear so that the valves do not get their proper travel. When only two rings of packing can be put in a stuffing box, it has to be screwed up so, to keep it steam- and water-tight, that the rods are soon worn in the middle and a shoulder formed at each end. In this condition the pump will not make its full stroke. With the valves properly set on a duplex pump, if the rod packing or the piston packing in the water end is too tight on one side, the stroke of the piston on that side will be too short, while on the other side it will be too long.

If the pump has been in use for several years and there is any doubt as to whether your predecessor has neglected the valve and cylinder lubrication, disconnect the exhaust pipe and let the pump run against a pressure. If the exhaust is short and sharp, it will be known that everything is all right, but if a continuous blow is heard between the exhausts, it will be found

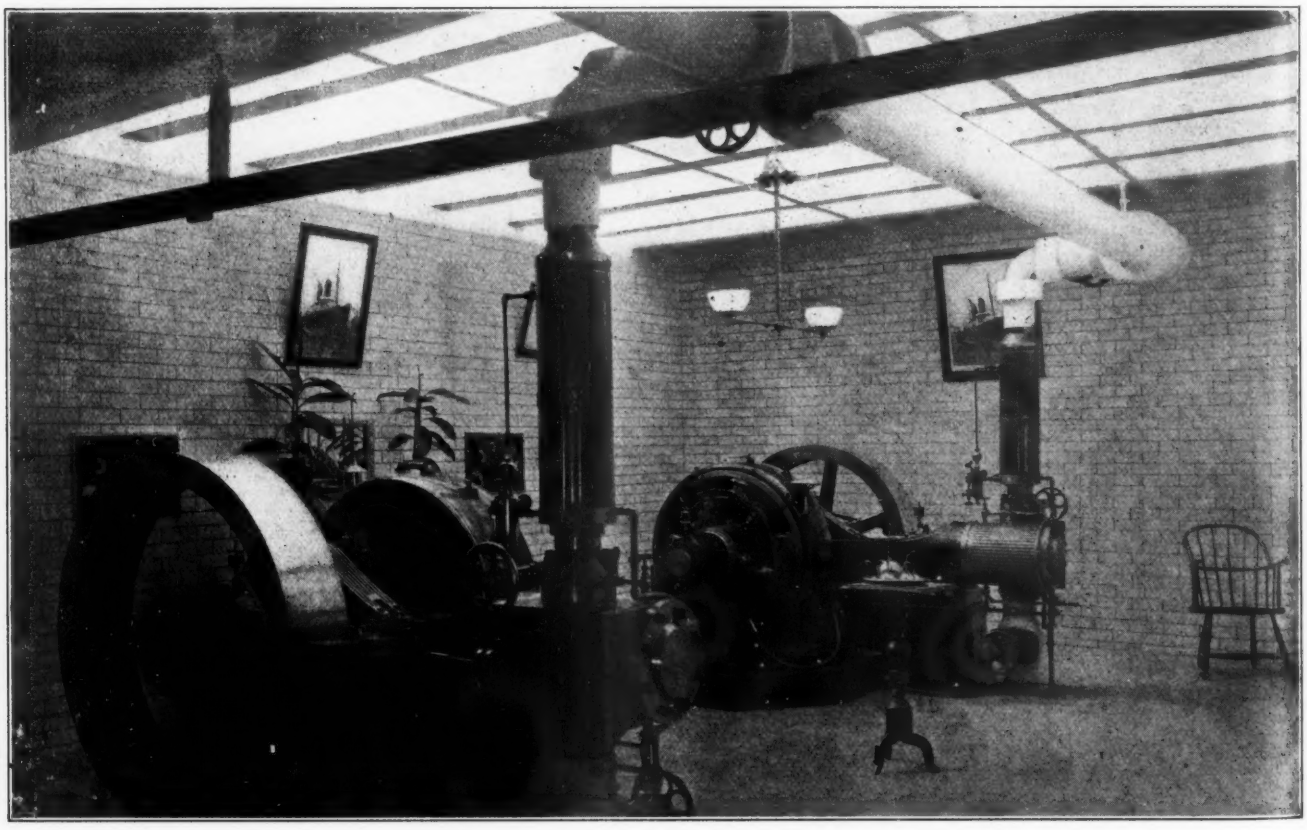


FIG. 1. ENGINE ROOM LIGHTED BY SIDEWALK SKYLIGHT ROOF

that the valves and valve seats are worn so that steam is leaking past the side of the valves into the exhaust port. This is on the supposition that the pistons in the cylinder are tight.

Next take off the entire steam chest, put a scale on a steel straight edge on the valve, also on the valve seat. If they are found badly worn, as they doubtless will be, take a fine flat file and carefully file down both valves and valve seats until the straight edge will touch every part. Then scrape to a good fit, using a little red lead and oil on the valve face, and work the valve back and forth on the seat until both are fitted. Now loosen the packing, at the same time prying the rod toward the water end until the piston touches the cylinder head. Make a mark on the rod next to the packing gland, then pry it back toward the steam end until the piston touches the cylinder head. Make another mark on the rod next to the packing gland, as before, and then take a pair of dividers or a rule and locate a point half-way between the two marks, and make a third mark. Move the rod toward the water end until the mark last made comes up flush with the gland, and the piston will be exactly in the middle of the cylinder. Treat the opposite side in a similar manner, and both pistons will be at half stroke.

Now put on the steam chest and set the valves so that they will be in the middle of their travel. The valves should just cover the parts line and line. If the lost motion is not equal with the valves in this position, take out the pin connecting the valve rod with the valve stem and screw the valve stem in or out of the valve nut until the lost motion is equalized. Put on the steam-chest cover, tighten the glands and start the pump, which should have plenty of oil until the new faces on the valve and seat have attained their polish, when the amount of oil can be reduced. If the pistons have too much travel, reduce the lost motion in the valve gear and *vice versa*. If the rods are much worn, they should be taken out and turned up in a lathe. A larger packing will then be required.

With regard to the water end, do not try to pump hot water with soft-rubber valves, nor with a solid brass plunger pump unless it is outside packed. Use composition or hard-rubber valves for hot water, and examine them often if the plate between the valve and spring is too small, which is often the case. The valve should be turned over if it becomes convex on the under side. Old valves can be made nearly as good as new by bringing them to a face on a sheet of fine sandpaper. Lay the sandpaper, cutting side up, on a smooth board and draw the valve back and forth over it. See that there is no leak in the gasket between the cylinder head and the water end, and also see that there are no leaks in the gasket between the suction valves. Do not get the springs too tight on the suction valves, for in this event the pump will not take water. Watch for leaks in the suction pipe, and if the piston packing in the water end does not last as long as it ought, examine the sleeves, and if they are badly scored or rough, have new ones put in. Do not crowd the new piston packing in too tight, leave it a little chance to expand.

Catechism of Electricity

776. *Can counter electromotive force be measured directly?*

No, but it can be calculated for any load on the armature by subtracting the voltage drop in the armature circuit at that load from the voltage applied to the brushes of the motor in order to run it.

777. *How is the voltage drop ascertained?*

By multiplying the resistance of the armature circuit (measured between brushes) by the current which flows at the load under consideration.

778. *What relation exists between the armature speed of a motor and the armature current?*

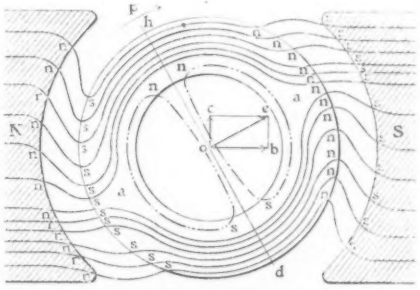


FIG. 268. DISTORTION OF THE MAGNETIC FIELD OF A MOTOR

The current varies oppositely to variations in the speed, when the motor is supplied from a constant potential circuit. That is, when the speed increases, the current immediately drops in value. If the difference between the applied and counter electromotive forces be divided by the resistance of the armature circuit, the result will be the current passing through the armature.

779. *Does not a motor take a very large current in starting from rest?*

It does, because the internal resistance of the armature is very small and the counter electromotive force at standstill is zero. If this current were maintained for any considerable length of time it would damage the armature, but as soon as the armature begins to move the current diminishes, until in a very short time the speed of rotation and, consequently, the counter electromotive force become sufficiently high that only a small current can flow through the armature.

780. *Does not this decrease of current lessen the force tending to cause the armature to revolve?*

It does. Early inventors tried to get rid of counter electromotive force because it limited the amount of current that passed through the armature, but soon found that their ideas were wrong.

781. *Have the lines of force developed by the current in the armature coils of a motor any effect upon the direction of lines of force produced by the field magnet?*

Yes, a distortion of the magnetic flux occurs, somewhat as shown in Fig. 268. The amount of distortion depends, as in the case of a generator, on the relative strengths and the relative directions of the magnetic fields developed by the armature and field magnet. A very slight distortion occurs when the field magnet is strong in comparison with the armature. In order to prevent sparking at the brushes it is necessary, as in the case of a generator, to set the brushes along a line practically at right angles to the resultant lines of force. The direction of the resultant lines of force of a motor is such in most cases that the brushes must be shifted backward, or opposite to the direction of rotation of the armature, in order to obtain sparkless commutation.

782. *Explain more fully the effect of the distortion of the field of a motor upon the position of the brushes.*

Referring to Fig. 268, *a a* represents the iron core of an armature rotating in the direction of the arrow *p* between the field-magnet poles *N* and *S*. Assuming the direction and intensity of the lines of force of the field magnet alone to be represented by the direction and length of the line *o b*, and the direction and intensity of the lines of force of the armature by the direction and length of the line *o c*, the diagonal or resultant *o c* of the rectangle thus formed represents by its direction and length the direction and strength of the resultant field.

The resultant lines of force *n s*, *n s*, etc., pass through the core of the armature in the direction indicated by the diagonal line *e*, and the brushes, to be set on a line at right angles to the resultant field, must be placed on the line *h d*.

783. *Do the magnetic lines of force heat the field magnet?*

Not directly, but if the poles are not laminated, eddy-currents will be generated by the lines of force at those parts where the field is of greatest density, and these will tend to heat the pole tips which are diametrically opposite to each other.

784. *Does the resultant field of a motor change its direction sufficiently during operation to necessitate a change in the position of the brushes?*

If the load on a motor fluctuates widely, the current through the armature will vary considerably, and the resultant field will change in direction. This may require a movement of the brushes to prevent sparking, but if the strength of the field produced by the magnets be made very powerful in comparison with that

produced by the armature, the resultant field will change so little that no sparking will result from the usual variation in the armature current due to fluctuating loads and the position of the brushes will not have to be changed.

785. *Is there any disadvantage in using very powerful field magnets?*

If the magnet be made very powerful the weight of the motor will be much greater than if a weaker magnet were used, but the advantages gained by the use of a powerful field magnet more than offset the expense of the extra weight.

786. *Do hysteresis and eddy currents in the magnet poles affect the resultant magnetic field of a motor?*

Yes; they shift it slightly in the direction of rotation, so that the brushes require less shifting from the exact midpole position in order to prevent sparking than if there were no hysteresis or eddy currents.

787. *Explain why the brushes of a motor should ordinarily be set along a line at right angles to the resultant magnetic field to prevent sparking.*

Refer, for example, to the armature coil

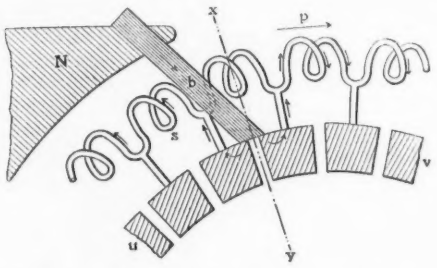


FIG. 269. ILLUSTRATING COMMUTATION IN A MOTOR

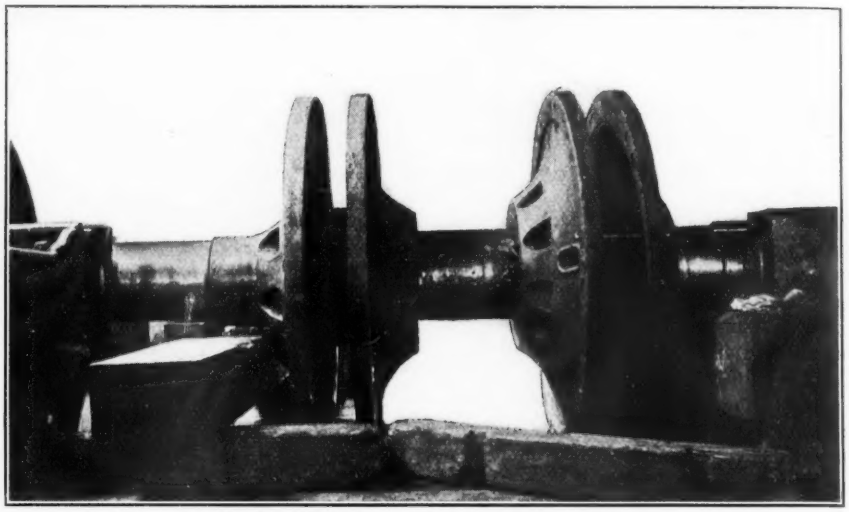
s, in Fig. 269, which is rising on the left while the armature is rotating in the direction of the arrow *p*. Current is passing through the coil *s* from the brush *b* as indicated by the other arrows. At the same time the coil *s* has induced in it a counter electromotive force which opposes the flow of this current. In order to prevent sparking between the brush and the commutator when the bar connected to the coil *s* passes under the brush and the short-circuit of the coil is broken, this action must occur when the coil is moving in a field which will be just strong enough to reverse the direction of the current in the coil without changing its value appreciably. If the bars connected to the coil pass under the brush when the coil is just leaving the magnetic field from the tip of the pole *N* in the diagram, this condition will be sufficiently well obtained and there will be little if any tendency to sparking.

A suction gas-engine outfit is being tried out on the old English warship "Rattler," with a view to determining the practicability of this type of ship propulsion.

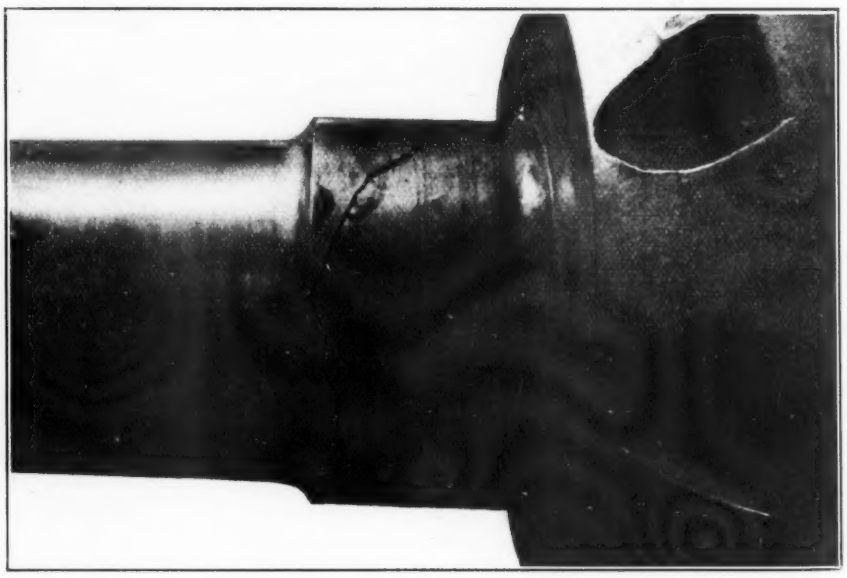
Failure of an Engine Shaft

About the middle of the forenoon of August 31, 1908, the engineer of the Seaconnett mill No. 2, Fall River, Mass., noticed a heating of the main bearing of the engine driving the mill. He immediately "slowed down" the engine, and by the application of water reduced the shaft and bearing to a safe running temperature, but in a very few minutes after the engine was again brought up to speed the bearing was dangerously warm and the engine was again "slowed down" to prevent further heating. While the engine was moving slowly, the superintendent, who was naturally drawn to the engine room by the interruption in the service, noticed a "wink" in the shaft between the main bearing and the flywheel. The engine was immediately stopped and a fracture extending half way around the shaft was discovered. The shaft at the break has a diameter of 19 inches and carries a flywheel 25 feet in diameter, of 100-inch face and weighing 100,000 pounds.

The engine was a 36x52x72-inch tandem compound Corliss, running at 75 revolutions per minute and was developing 1300 horsepower at the time of failure. It was installed in 1894 and has been run about 60 hours per week for the past 14 years. The photographs show the double flywheel hub and the location of the crack in the large diameter of the shaft.



SHOWING DOUBLE-FLYWHEEL HUB



SHOWING FRACTURE IN SHAFT

Conjecture as to the cause of the failure may be entirely out of place without further information, but it would seem at first glance that the shaft was probably made of iron built up at the forge in the usual manner under hammers that were too light for the work of forcing the iron into intimate contact during the welding process.

Condensers and Air Pumps

By W. H. Booth

A French engineer, M. Maurice Leblanc, has put the whole practical science of the steam-engine condenser into the form of a paper presented to the Association Technique Maritime, of Paris. Needless, almost, to say, the steam turbine has been the cause of very considerable attention being paid to the condenser and air pump. Much has been heard about the greater benefit that is secured from more perfect vacuum in the case of turbines than of reciprocating engines, but it is very much to be questioned that any of this benefit is to be credited to any difference of principle. It is rather to be explained on the ground that whereas the cylinder of a reciprocating engine only communicates with the condenser by way of narrow passageways and restricted ports, the cylinder of the turbine is open-ended to the condenser, the exhaust pipe being of much greater area in fact than the engine cylinder. The restricted passageway for the exhaust steam from the reciprocating engine is a matter of the exigencies of practical construction — a compromise between efficiency and bulk. The narrow passages hold back the steam, and the pressure in the cylinder does not fall any farther after the condenser pressure has fallen below what corresponds with 24 or 26 inches of vacuum more or less. Of what use, therefore, can it be to reduce any farther the condenser pressure, when by doing so the feed water is chilled at its source and the efficiency of the air pump is reduced?

It Pays to Carry High Vacuum for a Turbine

An immediate result of a better vacuum is that the old air-pump capacities are no longer always sufficient. They would be still more deficient were it not for the fact that there is less air to be dealt with, for the turbine offers less opportunity for the leakage of air than does the reciprocating engine. However this may be, it has become the practice to employ compound air pumps. Just as in the steam engine, expansion is carried out in two stages or more, so in the air pump better effects may be got out of a two-stage effect.

The air in a condenser is very attenuated when the absolute pressure is reduced to, say, only one pound per square inch. Of this total, only a portion is due to air pressure. Let it be assumed that the air, if present alone, would exert a pressure of only a fourth of a pound. In that case the air taken into the air pump would require to be compressed nearly sixty times for any of it to be discharged to the atmosphere, and this demands an air pump that shall possess no clearance space. There must always be some water to discharge at each stroke in order that all clearance space shall be filled right up to the under side of the discharge valves.

Air- and Water-vapor Pressure

When an air pump takes its fill of mixed water vapor and air and begins to compress it, the vapor will not be compressed to any higher pressure. If, as before, the total pressure is one pound absolute, made up one-fourth of air and three-fourths of water-vapor pressure, then is this three-quarters of a pound the pressure proper to the water temperature, and but for the air present the vacuum would always be simply the absolute pressure corresponding to the water temperature. This being so, when the air-pump bucket begins to reduce the imprisoned volume, the water vapor goes back into water, and the air takes on a higher pressure. The water vapor never rises above the ¾ pound proper to the temperature, but the air pressure becomes 14 pounds. Then $14 + \frac{3}{4} = 14\frac{3}{4}$, or atmospheric pressure, and the discharge valve opens to let out the air. But, plainly, it cannot do so unless the clearance is very small, less than ⅛ inch in a bucket stroke of 7 inches, for $14 \div \frac{1}{4} = 56 = 7 \div \frac{1}{8}$. Now seeing that the presence of air in a condenser always adds the air pressure to the water pressure, the importance of air removal is obvious. How can a condenser be worked so that the vacuum is that proper to the water temperature, so that the joint pressure of the water vapor and of the air, according to Dalton's law of mixed vapors, shall be circumvented.

The Law of Mixed Vapors

For the benefit of those who have not studied this law and its effects, it may be briefly explained. In the space above any liquid at a given temperature, there must always exist the vapor of that liquid at the density proper to the temperature of the liquid from which it rises. This weight of vapor must exist in that space irrespective of what other vapor is present at the time. Thus if there be water at 212 degrees Fahrenheit in a closed vessel, the space above that water will be filled with steam at a pressure of 14.7 pounds per square inch, absolute. Let it be assumed for clearness that this space is of 1 cubic foot capacity, and that there be now pumped into it 1 cubic foot of air, also at 212 degrees Fahrenheit and at 14.7 pounds pressure. Then the pressure in the vessel will be $14.7 \times 2 = 29.4$ pounds. The forcing in of the air has not driven back the water vapor into water, but both the gaseous fluids exist together, and their joint pressure is the sum of what each vapor would exert separately.

At first sight, it would appear as though the forcing in of air would drive the water vapor into the water, leaving a pressure of only 14.7 pounds, but it is not so. This fact serves to explain how it is that, when steam has been got up in a newly filled boiler to, say, 100 pounds on the gage, the pressure will drop 10 or 15 pounds or more as soon as the valve to the engine is opened. For it was the air pressure added to the water-vapor pressure which was shown by the gage. A thermometer would have shown that the boiler had not attained the temperature proper to 100 pounds. In practice this is avoided by blowing off the imprisoned air at the safety valve as the steam pressure rises.

Withdraw Air from Condenser at Its Coldest Part

Now M. Leblanc endeavors, among other things, to show how the working of the law of mixed vapors may be so utilized as to secure that the vacuum in a condenser shall not be less than that proper to the water temperature, and this can be managed if the air is withdrawn from a condenser at its coldest part. Of course, there must be a coldest part, and this it is the designer's duty to arrange for in his design. It may be supposed that a condenser consists of a series of chambers of water through which pass the circulation water tubes. Clearly the chamber nearest the entry end of the water tubes will be the coldest, and the chamber at the other end of the series will be hottest. From each box of water will rise vapor whose pressure is that proper to the temperature of that particular box or chamber. But if all these boxes are shut up in a closed chamber, there will be in that main chamber but one pressure, for it is practically impossible in a capacious chamber that the pressure at one part can differ from that at another. The pressure must be equal at every point, and in order that it may be so, there will be a steady flow of vapor from above the hotter boxes of water toward the colder boxes. This stream of vapor will flow into the colder water and condense there, and the flow will continue until so much heat has been abstracted from the vapor rising from the hot water and carried as latent heat to become sensible again in raising the temperature of the colder boxes. Finally, both temperature and pressure will be equalized throughout, and all further movement will cease.

In a condenser there are so many cold-water tubes and there is a constant formation of water going on and this water is continuously abstracted.

If the condenser is long, the water at one end will be cooler than that at the other end, so that if the water be abstracted from the hotter end, there will be a steady flow of water to the hot end, and the temperature of the hot end will fix the pressure below which it is not possible to go, but down to which M. Leblanc says it is possible to get, "if the air is withdrawn from the coldest portion of

the condenser." How is this brought about? By means of the flow of the mixed vapors, which constantly endeavor to equalize the pressure in the condenser.

Compounding the Air Pump

It has been seen in the hypothetical case of the separate boxes how the flow is from the hotter toward the colder boxes. So in the condenser there must be equalization. The vapor, with its mixed air, flows toward the colder parts, and so it happens that at one end of the condenser the pressure is, say, one pound absolute, made up of 0.75 pound of aqueous vapor pressure and 0.25 pound of air pressure, while at the other end the pressure is also one pound made up entirely of vapor pressure, all the air having been swept toward the colder parts, whence it is withdrawn by the dry-air pump. Thus the air pump draws a minimum of water vapor and a maximum of air. When the air pump is compounded by the use of a rotary exhauster or of a steam-jet augmenter, the air is, so to speak, gathered up and piled into the barrel of the true air pump at a pressure absolute, which may be three or four times that of the condenser. The true air pump, therefore, gets so much more air every stroke in proportion to the piling-up effect of the first-stage pump.

The use of a steam jet is common for this purpose. It induces a flow of air toward the pump, but it is somewhat contrary to Leblanc, insofar that it is introducing heat at the cold part of the condenser and demands a supplementary set of cold circulating tubes to condense the steam. Theory would, therefore, favor the rotary exhauster rather than the steam jet for this first-stage effect. Indeed the steam augmenter seems to have been designed regardless of the Leblanc system, as it may be called, of utilizing the law of mixed vapors to purge the air from that part of a condenser whence the wet pump draws off the water.

Condensation a Haphazard Operation

Since air is much heavier than water vapor, the ratio being about 15 to 9, it follows that the air should be drawn out at the lowest point of a condenser, and not at the highest, as is usually done. Therefore, the circulating water should enter at the lowest point and leave at a higher level, and the steam to be condensed should enter at a high level and travel toward the colder lower tubes. But since the condensed steam will descend as water by gravity, this shower of water must be caught at several points in its descent and promptly delivered to the water-outlet point. At the same time there must be a free vapor communication from all points to the place of air withdrawal, in order that the air may be swept to the point of discharge and the best vacuum secured after the manner described.

These several demands are more or less inconsistent with one another, and it is possible that after all the air may best be withdrawn at a high level; that its heavier density may not vitiate after all the upsweeping energy of the general vapor flow, when entering low down. But, in any case, the water should enter so as to chill the outgoing air, and the hot water should be removed promptly, so that the maximum temperature in the condenser shall be as low as possible. M. Leblanc suggests a water jet in place of a steam jet as a vacuum augmenter. This would be suitable for a jet condenser. In any case the double staging of the air pump enables the second stage to act very much more efficiently. But the law of mixed vapors and the effects that rise from it, must be given proper consideration in the design of condensing apparatus. Until recently, however, condensation has been a somewhat haphazard operation, and everything in the working of condensers and air pumps has been purely casual.

Automatic Injector Information

By Frank O'Leary*

In the selection of an injector, the prime consideration must be the selection of a machine best suited to the conditions under which it is to work. Relating the manner in which injectors are classed as positive, automatic, lifting and nonlifting, a confusing impression is conveyed of there being many types of injector. An automatic injector may be a lifting or nonlifting machine, according to its construction; so a positive injector may be a lifter or nonlifter. Therefore, there are but two distinct types, automatic and positive. While a lifting machine might work under nonlifting conditions, or a nonlifting machine work on a very short lift, their usefulness would be limited as compared to their service were they connected in their proper condition.

A lifting injector is constructed to be used where the pressure of the atmosphere alone overcomes the weight of the water, forcing it upward into the constantly forming vacuum caused by the condensation of steam in the instrument.

A nonlifting injector is designed to be used where the water flows to the injector, as from tanks above, from city mains, etc. More generally the requirements are for lifting injectors. There are accordingly more of this class manufactured than of the nonlifting type, consequently the lifting injector is more frequently erroneously applied to nonlifting conditions, than is a nonlifting machine to lifting conditions. There is no remedy which may be applied to a nonlifting injector that will make it work satisfactorily when used where lifting is required.

A lifting injector properly constructed, working under average boiler pressure, say 100 pounds, should deliver to the boiler 12 to 16 pounds of water per pound of steam used. It is plain that with the combined pressure of the atmosphere and its own weight, a greater volume of water will flow downward into a partial vacuum than the weight of the atmosphere alone is capable of forcing upward in the same vacuum, when it is considered that in the latter case the weight of water acts against the atmospheric pressure. Therefore, by applying the lifting injector to nonlifting conditions, it is apparent that the amount of steam used will be practically unchanged, while the volume of water will be much greater, the result of which is a disproportionate amount of water for the steam power of the injector to force to the boiler. Since many a good injector has been condemned for no other reason than that it was applied to conditions other than for which it was designed, and that thoughtless selections are the prime cause of trouble to the engineer and manufacturer, let the inexperienced in selecting an injector advise the representative manufacturer, should his conditions be different from those taken to illustrate the general instructions in catalogs.

The very small proportions of the injector in comparison to the work it performs, immediately suggests to the considerate engineer that the prime parts of the device must necessarily be of delicate and precise dimensions, and that he must exercise his mechanical knowledge to connect the instrument to the boiler in a careful and workmanlike manner. When the piping is accurately fitted, steam should be blown through to carry out scale and pieces of cuttings, which are sure to be in a new pipe arrangement. The suction or supply pipe from the tank or other source from which the injector takes water, is the line which gives the most trouble. This is due to the fact that when the injector is connected to lift, the only pressure on this pipe is the air pressure on the outside, the force of which is inward. This pipe will not show leakage, because it is leaking air in, not water out, and since it does not show leakage, the engineer often assumes it to be tight. It is therefore desirable to be careful in screwing up this pipe, so that it will be known to a certainty that it is tight.

Why the Injector often Fails to Work

To illustrate the most annoying and frequent reason why the injector fails to work, refer to the accompanying sectional view of a steam-suction and delivery tube of a Penberthy injector, which may be used as a general example. It will be seen at *A*, in the delivery tube *Y*, that

*Mechanical engineer of the Penberthy Injector Company.

the inlet taper *B* and the outlet taper *C* extend into a straight bore, at which point the highest velocity of the water is attained. This is the smallest bore in the instrument. Particles of pipe cuttings, coal or gravel coming from the steam or suction pipe would find their way through the wide tapers of the suction jet *S* and through the contracting taper *B* of jet *Y*, until the smaller area of bore at *A* would block their passage, when this bore and the spill holes *D* would be stopped up, as shown.

If on first trial the injector fails to work, or if the injector has worked and suddenly stops, the engineer would remove tube *Y*, hold it endwise to the light and examine this particular point *A*, and would almost surely find that it had become plugged. When the tube is found to be stopped up, a small wire may be run through the bore and tapers, which will push the obstruction out. The wire should be entered at the end of the tube *E* and pushed through toward end *F*. Often the engineer removes this tube and closely examines it on the outside, but neglects the inside; seeing nothing wrong, the injector is considered defective and returned for repairs, only for the manufacturer to discover the jet stopped up. Too much care cannot be taken to keep the injector clean and free of lime.

A Practical Test

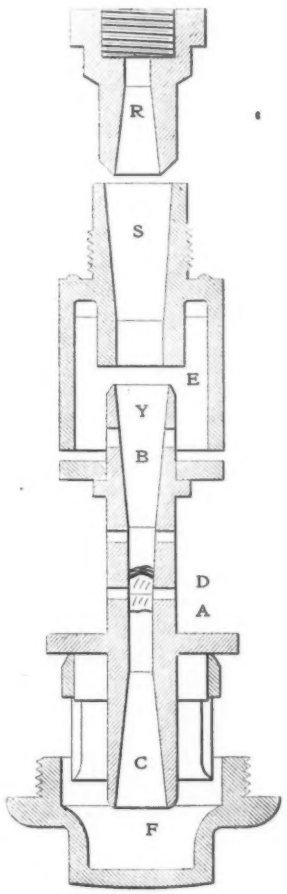
It may be interesting to consider a practical demonstration of the operation of a Penberthy automatic injector in the shape of a test made with a DD-21 machine, having a 1¼-inch pipe connections. The injector was connected to the boiler in the usual manner, but with the delivery pipe arranged in such a way as to permit the attachment of an equalizing valve through which the water, after overcoming boiler pressure on the valve, was delivered to a tank placed on platform scales. The intake pipe was so attached as to average a lift of 3 feet from a tank, also held by platform scales. This tank contained sufficient water for the test, the temperature of the water being 70 degrees Fahrenheit. This method permitted an accurate computation, as, before the discharge from the injector could reach the receiving tank, it was necessary for the injector to overcome boiler pressure existing on the equalizing valve. The boiler pressure throughout the test was 100 pounds gage, and the duration of the test was five minutes, which is ample time from which to compute an average performance.

Weight of Water

In the five minutes the injector had taken from the supply tank 646.59 pounds of water and had delivered into the receiving tank 692.04 pounds. The temperature of the water was increased in its passage through the injector from 70 degrees to 147 degrees Fahrenheit. The difference between the weight of the water taken from the supply tank and that delivered into the receiving tank was due to the addition of the condensed steam used by the injector; this amounted to 45.45 pounds, and the quantity of water delivered per pound of steam used, was

$$\frac{646.59}{45.45} = 14.224.$$

To prove the ratio correct and to ascertain something of the velocity of the steam and water through the injector, we will reduce the water to cubic feet, noting its weight and volume at the temperature at



VERTICAL SECTION THROUGH INJECTOR

which it was taken and at which it was delivered. One cubic foot of water at the temperature 70 degrees Fahrenheit weighs 62.35 pounds; the amount taken, 646.59 pounds, would equal as many cubic feet as the number of times it would contain the weight of 1 cubic foot, which is

$$\frac{646.59}{62.35} = 10.3769$$

cubic feet. By the application of heat, the water in its passage through the injector has been raised from the temperature 74 degrees to 147 degrees, at which temperature 1 cubic foot of water weighs 61.24. The 646.59 pounds as delivered would equal

$$\frac{646.59}{61.35} = 10.5582$$

cubic feet.

The expansion would be determined by subtracting the volume of 646.59 pounds at a temperature of 74 degrees, from the volume 646.59 pounds, at a temperature of 147 degrees, which is

$$10.5582 - 10.3769 = 0.1813$$

cubic foot. Therefore, without adding to its original weight, the water taken has been increased in volume 0.1813 cubic foot.

Weight of Steam

Including steam used and condensed in the operation, the total weight of water in the receiving tank is 692.04 pounds, which weighed at a temperature of 147 degrees, equals a volume of 11.3004 cubic feet. To find the number of pounds of steam used, subtract the volume of supply (10.5582 cubic feet), as it was delivered to the receiving tank, from the combined condensation and supply (11.3004 cubic feet)

$$11.3004 - 10.5582 = 0.7422$$

cubic foot. We have, therefore, used in the performance a volume of steam equal to the weight of 0.7422 cubic foot of water at the temperature of 147 degrees. The weight of 1 cubic foot of water at the temperature 147 degrees being 61.24 pounds, 0.7422 cubic foot would weigh

$$61.24 \times 0.7422 = 45.45$$

pounds of steam used.

Velocity of Steam

To determine the velocity of steam through the steam tube into the injector, refer to a table of weights of saturated steam and find that at 100 pounds gage pressure, 1 cubic foot of steam weighs 0.2617 pound. The number of pounds used in this test would thus be

$$\frac{45\ 45}{0\ 2617} = 173.6721$$

cubic feet used.

The diameter of bore through which the steam entered this injector was ⅜ inch, which diameter equals a square area of 0.1104 inch. A cubic inch of steam, in order to pass through a ⅜-inch bore, would transform itself into a jet ⅜ inch in diameter by 9.0579 inches long. To pass a given point in a ⅜-inch bore, a cubic foot (1728 cubic inches) of steam would travel

$$1728 \times 9.0579 = 15,652.05$$

inches, or dividing by 12, would give 1304.3376 feet. As, during the test, 173.6721 cubic feet were used, the total travel may be found by multiplying 1304.3376, the travel of 1 cubic foot, by the total cubic feet, 173.6721, which will be

$$1304.3376 \times 173.6721 = 226,527.05$$

feet. The duration of test being five minutes, or 300 seconds, the velocity of steam through the bore will be de-

termined by dividing the number of feet of travel by the time; thus,

$$\frac{226,527.05}{300} = 755.09$$

feet per second, which is the velocity with which the steam enters the injector.

The diameter of bore through the section of the combining tube where the combined steam and water attains the highest velocity in the machine is 7 millimeters, which diameter closely approximates 9/32 inch, the area being 0.062 square inch. A cubic inch of water to pass this bore would take a form 9/32 inch in diameter by 16.129 inches long. As the amount of the delivery was 11.3004 cubic feet, or 19,527.0912 cubic inches, the total travel through this bore would be found by multiplying 19,527.0912 by 16.129 inches, which equals 314,952.454 inches, or 26,246.0378 feet. The duration of the test being 300 seconds, the velocity may be found by dividing the travel by the time, or

$$\frac{26,246.0378}{300} = 87.486$$

feet per second, which is the velocity of the water through the combining tube of the injector. This means that the injector is overcoming and feeding into the boiler pressure at this point at the rate of nearly 87½ feet per second.

Hygrometry in Its Practical Aspect

By J. H. Hart

In a large number of industries the effect of moisture in the air is very pronounced, and is in nearly every case deterrent to the best efficiency of operation, but until recently no practical attempts to remove it on a large scale have been made, and the subject of hygrometry has appeared in a theoretical rather than a practical aspect to the majority of engineers. However, the wonderful adaptation of mechanical refrigeration in the removal of moisture from the blast in iron-furnace operation, and its consideration in the operation of cooling towers, and also the possible application of mechanical refrigeration to the drying of blasts of any kind and wherever used, have brought the subject of moisture in the atmosphere, and the laws which govern it, to the notice of the practical engineer. While the subject of hygrometry is easily understood, there exist today comparatively few efficient methods of measuring it, and the majority of the devices utilize various systems of measurement, which render the obtaining of accurate knowledge readily, in this field, a comparatively difficult process. In fact, very little of any real value is known by the average engineer.

Degree of Saturation

The province of hygrometry is to determine the quantity of aqueous vapor contained in a given volume of air. This quantity is variable. The atmosphere is seldom, if ever, completely saturated with vapor, even in our climate, nor is it ever completely dry. The presence of moisture can be readily detected if hygroscopic substances, such as chloride of calcium or sulphuric acid, be exposed for any time to the air, as they absorb considerable water vapor. As the air is in general never saturated, the ratio of the quantity of aqueous vapor actually present in the air to that which it could contain if it were saturated, the temperature being the same, is called the hygrometric state or degree of saturation.

Absolute Moisture in the Air and its Variations

The absolute moisture in the air is measured by the weight of water actually present in the form of vapor in the unit of volume. There is this remarkable fact about vapors in general. Two vapors, or a vapor and a gas, will occupy the same space just as if the other were not present. Thus water vapor is present everywhere in the space surrounding the earth, and the quantity of this vapor depends simply upon the temperature of the vapor and its contiguity to a source of the liquid. If immediately in contact, it in general becomes saturated for that temperature in precisely the manner that steam becomes saturated in a boiler and remains so. A saturated vapor in this department has the same significance as a saturated vapor in steam or ammonia work. It means that if the pressure is increased or the temperature lowered, condensation occurs, or in other words, that the space contains all of the vapor possible at that pressure and temperature. Thus the space surrounding the earth contains water vapor independent of the quantity of air present and a function only of the temperature and degree of saturation.

Absolute moisture in the air varies with the temperature in the course both of the year and of the day. If summer, there is a maximum in the morning and evening and a minimum at 3 a.m. and 3 p.m., because of the ascending current of air which carries the moisture upward. The absolute moisture is greatest in the Tropics, where it represents a pressure of 1 inch of mercury, while in our latitude it does not exceed 0.4 inch. The relative moisture, however, is on the average greater in high than low latitudes. It is at its minimum in the hottest and at its maximum in the coolest part of the day. It varies in different regions, and is greater at a distance from a large body of water than when near at hand. Thus in England the relative moisture is about 80, in Italy about 60 and in Siberia about 40 per cent. When the air is cooled, the relative moisture increases until it ultimately becomes saturated. This accounts for the production of rain and dew and snow. They are invariably due to the cooling of atmospheric conditions below the saturation point of the aqueous vapor present.

Relative Humidity

Our judgment in regard to relative humidity varies greatly. In summer we say that air is very dry because it contains an average of 1/40 of a pound of water to the cubic yard, whereas it could contain twice this amount without condensation. On the other hand, in winter if the same volume contains 1/80 of a pound, we say it is very moist, because it is very near the saturation point and a very slight diminution in temperature produces a deposit. When a room is warmed, the quantity of moisture is not diminished, but the humidity of the air is lessened, because its saturation value is raised. The air may thus become so dry as to be injurious to the health, and hence rises the precaution of placing vessels of water in such a room.

Ratio of Pressures rather than Quantities

Boyle's Law applies to nonsaturated vapors as well as to gases, and the presence of another gas or vapor has no effect on the operation of this law. Hence, it follows that with the same temperature and volume, the weight of vapor in an unsaturated space increases with the pressure and, therefore, with the pressure of the vapor itself. Instead, therefore, of using the definition of hygrometric state as the ratio of the quantity of vapor present to the quantity of vapor present in a saturated state, it can be defined as the ratio of the pressure of the vapor which the air actually contains and the pressure of the vapor which it would contain at the same temperature if it were saturated. Thus if f is the actual pressure of aqueous vapor in the air, F that of the saturated vapor at the same temperature and N the hygrometric state, we have

$$N = \frac{f}{F},$$

whence

$$f = FN.$$

As a consequence of this second definition, it is important to notice that the temperature having varied, the air may contain the same quantity of vapor and yet not have the same hygrometric state, for when the temperature rises, the pressure of the vapor which the air would contain if saturated, increases more rapidly than the vapor actually present in the atmosphere, and hence the relation between the two forces, or the hygrometric state, becomes smaller.

Pressure, Temperature and Condensation

This relation N is what is generally measured in the majority of hygrometers.

Given this value and the pressure and temperature obtainable from other sources, the absolute moisture in the air, or the quantity of water present, can be calculated by suitable formulas. The absolute quantity of water present in the air can also be obtained directly by what is known as a chemical hygrometer. This consists of some hygroscopic substance which is weighed and then made to absorb all the moisture in a certain quantity of air. It is then reweighed and the quantity of moisture obtained by subtracting the two weights. This gives absolute values, and is the only thing of much importance in refrigeration work in the removal of moisture from the air. The only necessary factors to consider in a problem of this kind are: The quantity of air which must be furnished, the quantity of moisture that it contains and the temperature to which both must be cooled in order to condense moisture.

It is obviously impossible to cool the air to a sufficient extent to remove all the moisture if no limitations of pressure are considered, but in practice, with suitable pressures and temperatures, it is possible to condense almost the entire amount. The amount condensed for a given temperature depends primarily upon the pressure, and thus, in different applications of blast operation, different cooling temperatures must be maintained. The removal of the moisture from the air blast in iron-furnace operation increases the production of the iron, on account of the saving in heat and its concentration in the furnace. Water vapor has a high specific heat and, when injected into the furnace, absorbs large quantities of heat in its passage. Further, a process analogous to that in the production of water gas goes on and the water vapor present at this high temperature is decomposed with the subsequent loss in the furnace of its heat of decomposition. This decomposed material unites with carbon partially and goes on into the exhaust, where it gives up its heat by recombination and further increases the heat waste in the exhaust. It is analogous in this respect to the nitrogen present in the air, but is tenfold as destructive in its effect. The cooling of the air is lost in the furnace, since the air must be reheated, and further, the degree of cooling affects the efficiency of the refrigerating device; hence, all of these factors must be considered in determining the degree to which air must be cooled and no fixed values can be given. Sufficient data are not at hand and results can only be obtained from practice.

Behavior of Water Vapor in Air

Of course, it goes without saying that air can be cooled more efficiently from a practical point of view when under pressure, and the process of removal of the moisture continued more efficiently; but the behavior of the water vapor during compression of the air is an important factor and also enters to disturb results for best efficiency. The best method of considering the behavior of water vapor in air and its effect on efficiency, is to regard it separately in all its changes. Thus when air is compressed and has water vapor in it, we can get the best conception of the results by regarding each material as separated and the process performed in this state followed by a recombination. Thus water vapor, if separated and compressed, will condense partially, if not heated at the same time, and a consideration of the phenomena that occur under these conditions shows results exactly similar to those holding in steam work. In general, with increase in pressure on a condensable vapor at its saturation point, there results a considerable condensation which gives out its heat of liquefaction. If air is compressed, the work done on it heats it somewhat, and the presence of water vapor, also compressed, heats it still more on account of the condensation of the water. The mixture of water vapor and air may be heated to such an extent as almost to evaporate the water again, but the general result is to increase the working pressure of compression, thus diminishing the efficiency of the plant.

Air a Convenient Carrier for Water Vapor

In general it can be said again, the whole phenomenon of moisture in air and its application can be best considered by regarding the moisture as occupying the space independently of the air present. Thus in cooling towers and drying devices of all kinds, advantage is taken of the fact that an unsaturated vapor tends to become saturated when immediately in contact with a liquid of its own substance, and tends to remain so. In cooling-tower work we can neglect the presence of the air and regard the space surrounding the cooling tower as filled with water vapor, in a more or less saturated condition. The presence of the air is an advantage from a mechanical point of view, simply by furnishing a convenient carrier for the water vapor, or by offering something by which the water vapor can be conveniently held and moved, so that the efficiency of a cooling tower depends absolutely on the quantity of saturated vapor which can be brought into immediate contact with the water, and this depends, within certain limitations, upon the quantity of air which can be brought under the same conditions and upon the surface of the water to be cooled. A great mistake is often made in cooling-tower practice by using fans to drive the air rapidly through the entire length of the tower. The air is merely a conveyer of the unsaturated water vapor. This becomes saturated almost immediately upon contact with the first layer of water in the tower and the further progress of this saturated vapor, and the air which drives it, is a distinct economic loss in the operation of the plant.

Warm Air for Cooling Tower

Today it is generally recognized that atmospheric cooling towers are much superior, from an efficiency point of view, to those operated by fans. A mistake is often made in this practice by considering the temperature of the substances involved. Unsaturated water vapor which has been heated requires a greater additional quantity of water to make it saturated. Hence it is much better to use warm air in a cooling tower than cold, anomalous as this statement may appear. The cold air does cool off the hot water to a certain extent by conduction and contact with its surface, but air is notoriously a poor conductor, and hence the advantage derived from this factor is very small. Hot air means that the water vapor is hot also and less saturated than before, if such a term can be used, and the relative humidity N, as has been used in the preceding formulas, is much less. This is a point which should not be lost sight of in cooling-tower work, or drying work of any kind, and modern practice seems to bear out this statement.

As a further application, the utilization of superheated steam as a drying device is a distinct example of this development. Superheated steam, although very hot when allowed to go over moist materials, rapidly absorbs the water from them and actually cools them below their former temperature, although the amount is nowhere near as great as in cooling-tower practice, since the water vapor in contact is a fairly good conductor of heat.

Wet-bulb Hygrometer

In regard to the development of modern applications in this field, results can only be obtained by determination of the actual quantity of water vapor present per unit of volume. Various instruments, in addition to the chemical hygrometer, have been developed for measuring N. The devices are purely empirical in their methods and in the results attained. Thus the wet-bulb hygrometer consists simply of two thermometers, one of which registers the temperature of the air and the other registers a different temperature which is attained by the following process: The bulb of the thermometer is surrounded by lamp wick, which is connected to a small vessel containing water. The wick draws up moisture from the water and evaporation occurs from its surface into the air. The rapidity of evaporation depends upon the relative dryness of the air, or upon N. The water in its evaporation absorbs its own heat of liquefaction from surrounding bodies and produces a distinct cooling effect on the bulb of the thermometer, similar to that of the refrigerating machine.

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The Engineer's Library

It is impossible for a man to excel in all things, but he may in one thing. If a man is employed as an engineer he should aim to attain first place, but to do this he must read. The majority of engineers have been deprived of the higher school and college training, and no class of men realize this lack more than they who are of such importance in the industrial world.

There are books dealing with every department of mechanics and the arts, as well as of trade and finance, and the man who is content to learn from "experience," merely, is making a mistake. If he has no other opportunity of knowing how his brother engineers do their work, books will tell him.

The selection of a book because the title reads as if the book covered the desired subject, when in reality the apparent aim of the author is to fill a certain number of pages with matter which does not say anything and illustrations which do not illustrate, is a great mistake. Life is too short to trifle with such books. George Washington once wrote: "Books are waste paper unless we spend in action the wisdom we get from them." Therefore, great care should be exercised in purchasing books for one's library.

How can one know what books to purchase? This question has puzzled a great many engineers. There are several methods—one is to get the opinion of some engineer whose judgment can be relied upon; another is to obtain from the publisher, before purchasing, a synopsis of the volume desired. If it contains matter dating from the time of Hero to the present, including all the different engine and boiler types, do not waste your money upon it, because it is not possible for one such volume to contain sufficiently thorough information to be of value to the reader.

If you need a book treating of the early history of the steam engine, select one that confines itself to that particular subject. If information about valve setting is desired, do not purchase a book embracing boiler construction, etc. In short, choose books which deal with the question at issue and that alone, when possible.

The book cheapest in price is not always the cheapest in the end. Accuracy is, of all things, most essential, and a book containing discrepancies is practically useless, for one cannot tell which statement is right or which is wrong. Twenty-five books carefully selected, so that each treats of a different subject, are worth more in the engineer's library than one hundred in which the same ground has been covered over and over again, which is sure to be the case if the books are bought in a haphazard manner.

If every engineer who wishes to become better informed about his profession would spend the same amount of time with a few well selected books dealing with engineering subjects that he spends reading the scandals and political slush in the daily newspapers, he would be surprised at the intellectual progress possible in a few months' time.

Relocating Productive Machinery

Machinery location is one of the most important factors in economical production. Each new plant designed along progressive lines illustrates the modern tendency to avoid obstructions to the forward movement of materials and products between the stock room and the shipping department, through all the stages of fabrication, assembly and testing. The demand is for a minimum number of turn-backs from end to end of the plant. Under the provisions of a broad design it is not difficult to arrange for the most efficient sequence of operations in laying out a new installation, but in a long-established plant it is often a complex problem to adjust machinery locations to changes in methods of manufacturing or to modifications in materials and products imposed by new markets.

Minimum cost of manufacture per unit of product is the final test of any machine arrangement. The primary factor is the time element, secondary considerations being the proper mechanical installation of the equipment, the efficient supply of power, and the cost of relocation. Power supply through electric circuits, flexible shafting and air hose all offer great advantages in the practical consideration of relocation problems, since they enable trial locations to be made with a great variety of machinery. By checking the different processes and transfers of materials and products with a stop or second-hand watch, the best installation can finally be determined with reasonable accuracy.

With limited space and rigid shafting and belt installations the relocation of productive machinery becomes a matter of extreme difficulty in the majority of cases. It may cost so much to make the necessary changes that a new plant may be the only solution of the problem. Before reaching a decision, however, the possibilities of electric driving should be considered. A partial group or individual drive may increase the capacity of an old plant twenty or twenty-five per cent., permitting the placing of machine tools to avoid excessive doubling of materials upon their paths through the shops. The flexibility of the motor drive is too well known to need discussion here, but its possibilities in old plants in connection with the manufacture of new products or adoption of new methods are not always appreciated. It will pay in some cases to relocate several machines for driving in group by a single motor, even if the bal-

ance of the plant is operated by purely mechanical methods of driving, and current for the single motor be supplied from a local central station.

Complete data regarding the labor cost and time required for different operations, approximate cost estimates for remodeling floor and ceiling construction, need of special bracing, requirements in the line of re-piping and re-wiring, the space available for passing products and materials between machines, and the facilities for serving tools with their work, all need consideration in the relocation of machines to secure more rapid production or greater efficiency of service. It will pay in every case to make at least sketch plans to a good-sized scale, indicating machine outlines and aisle widths with diagrams of crane clearances and traveling-hoist facilities, temporary storage areas, floor and wall openings. In the final solution of a relocation problem the addition of a single air- or water-driven hoist may determine the success of the entire scheme from the standpoint of productive efficiency. The older and more congested the plant, the greater becomes the need of efficient and rapid handling of materials in all directions.

Gas and Steam Engine "Efficiencies"

The term "efficiency," of course, means nothing unless characterized, and even then its meaning is not always clear. However, we are not going to discuss that phase of the question just now; what we wish to point out is the fact that in comparing two widely different prime movers, such as the gas engine and the steam engine, it is a good plan to steer clear of all kinds of efficiency and get down to the direct relation between dollars spent and brake horsepower-hours obtained. This is not the whole story, by any means, as we have pointed out before. Reliability of operation—the ability to keep plugging along under all sorts of conditions — counts for more than economy, but that, too, is "another story." The relative cost of operation is what we are talking about, and that is not necessarily determined by thermal efficiency, mechanical efficiency or any other such narrow criterion. It is the cost in dollars per brake horsepower-hour that determines the relative economic merits of prime movers, and that cost includes fuel, oil, water (if any is bought), attendance, repairs, interest and depreciation. In many instances within the past few years, when the gas engine would have "passed" on the score of sufficient reliability, it has been turned down because the higher fixed charges and probably higher repair bills tipped the scale against it, notwithstanding its established higher thermal efficiency, fuel efficiency, or whatever you choose to call it. The prospect is brightening for a reduction in the maintenance expense for both gas engines and producers, and there are also indications of future reduction in the first cost. Should both prospects come to fruition, gas power will soon give steam power a hard race in those fields to which it is best adapted. At the moment, however, the high "efficiency" of the gas power plant means but little commercially, except in very special cases.

Engineers Should Form Social Ties

It is doubtful if engineers realize, even to a small degree, the benefits arising from freely mingling with fellow engineers, men whose daily duties are similar to their own. It matters not whether this commingling takes place in the form of the poorly attended meetings of the union or association to which he belongs, the convention to which he is a delegate or interested visitor, or one of the picnics or outings which knows his presence, the result is the same. It tends to a broadening of the mind, a brightening of the life and a resting of the body—a consummation to be wished for by all men, but by none more than the engineer.

Nowhere in the line of modern advancement has the change from former to present conditions been greater than in the work and responsibilities of the engineer. With the introduction of the electric light came almost simultaneously the high-speed elevator and the sky-scraping office building, made a commercial possibility by the advent of the light and the elevator. With these things, also, came the demand for a class of men to whose care they could be safely intrusted.

The engineer was naturally selected. Narrow as had been the field of his work, few as were his attainments, his was the only trade that furnished men with skill and training varied enough for consideration. While in all other lines the genius of the inventor had been engaged in supplying machines which should render human skill in many arts and trades superfluous, these same machines created a call for the engineer.

Men whose mental endowment and manual skill fitted them for the care and operation of power-generating and transmission machinery were and are still wanted, men on the borderland between the trade and the profession, the workers whose manual skill cannot be machine supplanted and whose mental work daily takes a higher plane.

The gain by association with others of this class cannot be calculated, and its value to the individual members of the class cannot be measured by commercial standards. Outings and picnics, "smoke talks," balls and ladies' nights alike have the same elevating tendency and should not be neglected. The engineer owes it to himself, to his family and to the community to be all that he can and as a member of an organization he is more than when alone; and if not already a member of some one of the numerous engineers' organizations, he should become one.

A Few Shares Left

The Tennesseean, a daily newspaper published at Nashville, Tenn., in the first columns of its front page calls attention to a three-piston six-cylinder engine designed by Levi Malugen and exploited through the efforts of George A. and J. J. Clark. It is stated that upon a test this engine developed 58 horsepower for one hour on a steam consumption of 4125 cubic feet, an equivalent of 25.3 pounds per horsepower-hour. Just how these figures are to be made to harmonize and check each other is not any clearer than Mr. Clark's statement that "this engine has practically revolutionized steam as a power." Also, 25.3 pounds of steam per horsepower-hour is given as the performance of the engine on test, and the statement is boldly made that this is less than one-half the usual steam consumption of the best engines now in use.

One is inclined to wonder a little at first why so much prominence is given to the engine and to the statements of Mr. Clark, who, by the way, is general manager of the Tennessee Central Railroad Company, and probably knows a great deal more about stock manipulation than about the economical performance of steam engines. But this mild curiosity disappears as it is learned that the Malugen Engine Company was chartered in Maine and a limited amount of stock may be subscribed for, as large blocks of stock were purposely reserved by the promoters for their friends and neighbors in and about Nashville.

Have You Seen This Bogus Subscription Agent?

Joseph M. Sheeran, who has recently been fraudulently representing himself as a subscription agent for POWER AND THE ENGINEER, and collecting money for subscriptions in Philadelphia, was arrested early Saturday morning, September 26, and held in $1500 bail for trial. As he was unable to furnish bail, he has been sent to jail.

Sheeran issued receipts for money collected and signed them either "Sheiren" or "J. H. Henderson." If any of our readers have been the victims of this fraud, we will be glad to have them send us full particulars.

One pound of average coal will evaporate one gallon of water, from and at 212 degrees Fahrenheit.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Mechanical Efficiency of a Gas Engine

Why is the mechanical efficiency of a gas engine so much lower than that of a steam engine?

C. K. L.

Chiefly because the gas engine is working half the time as a pump and partly because the pressures are much higher, entailing greater friction losses in the bearings. The mechanical efficiency of a gas engine is very little lower than that of a steam engine and its auxiliaries combined, which is a fairer comparison.

Attaching Lightning Rods

Which is the proper way to put on lightning rods, to insulate the conductor from the building, or to nail it to the walls and the roof without insulators?

W. T. C.

It is not necessary to insulate lightning rods from the buildings to which they are attached. Upon consideration you will realize that if lightning can jump thousands of feet from the nearest cloud to a lightning rod, insulators will not prevent it from jumping across a space of three or four inches between the lightning rod and the house, if the house should afford a better path to the ground, which is not at all likely.

Face Area of a Friction Clutch

How can I calculate the required size of face for a friction clutch to transmit a given horsepower at a given speed?

W. H.

The formula for face area is

$$\frac{40{,}123 \times HP}{d \times f} = \text{face area.}$$

Since the diameter must be assumed in order to use the formula, it is as well to calculate merely the width of the face, thus

$$\frac{40{,}123 \times HP}{d^2 \times f} = \text{face width.}$$

In both formulas

HP = Horsepower transmitted,
d = Mean diameter of clutch face,
f = Coefficient of friction = number of pounds that the clutch will pull at its mean diameter, per square inch of contact surface.

The friction coefficient varies widely with different materials and according to the pressure with which the surfaces are forced together. For leather against iron the friction coefficient is about equal to the pressure in pounds.

Determining Sizes of Wire for Electric Circuits

When an electric light or power feeder supplies two or three groups of lamps or motors, how is the size of the feeder wire determined? Use the accompanying sketch as an example.

J. E. T.

The feeder from the entrance block to the first branch block carries the entire load, which is 118 + 55 = 173 amperes. The distance is 60 feet and the allowed drop 2.2 volts. The feeder wire must, therefore, have a cross-section equal to

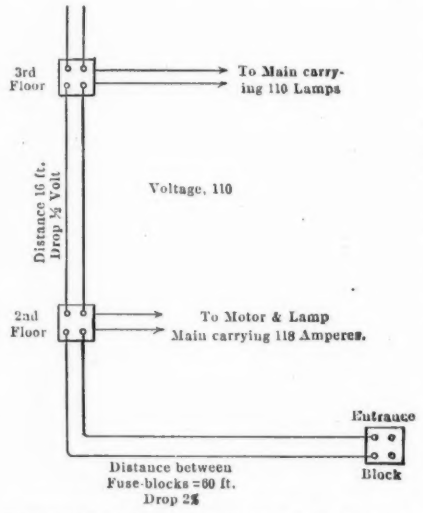
$$\frac{22 \times 60 \times 173}{2.2} = 103{,}800$$

circular mils. The nearest standard size is No. 0 with 105,500 circular mils of cross-section.

From the second-floor to the third-floor block the load is 55 amperes. The wire must have at least

$$\frac{22 \times 16 \times 55}{\frac{1}{2}} = 38{,}720$$

circular mils of cross-section. The nearest size is No. 4, with 41,700 circular mils.



DETERMINING SIZES OF WIRE FOR ELECTRICAL CIRCUITS

Checking back, the actual drop at full load will be

$$\frac{22 \times 60 \times 173}{105{,}500} = 2.16 \text{ volts,}$$

or 1.96 per cent., in the first stretch of feeder and

$$\frac{22 \times 16 \times 55}{41{,}700} = 0.46 \text{ volt}$$

in the second part of the feeder, or, more correctly, the sub-feeder.

Problems of this kind can be solved without calculation by means of the tables in Poole's "Wiring Handbook."

Mean Effective Pressure

Is mean effective pressure absolute or gage pressure?

J. S. K.

Neither, in a strict sense, but absolute pressures should be used in ascertaining it. It is the difference between the average value of the varying forward pressure and the average of whatever back pressure there may be. In a noncondensing steam engine, if the forward pressure be taken in absolute units, then the back pressure must be similarly taken, and conversely. For example, suppose the mean forward pressure is 55 pounds, and there is a back pressure of 20 pounds, both absolute. The mean effective pressure will be 55 — 20 = 35 pounds per square inch. The same result will be obtained by figuring with gage pressures, thus: Mean forward pressure = 40.3 pounds and back pressure = 5.3 pounds. Mean effective pressure, therefore, is equal to 40.3 — 5.3 = 35 pounds. It is best to figure all cases in absolute pressures because the pressures in compound and condensing engines must be so treated and it would lead to confusion if other problems were figured in gage pressures.

Racing Engine

I have two 20x40-inch Corliss engines exactly alike, but, when running, the governor of one rises 1 7/16 inches and the other only 13/16 of an inch and if the steam pressure drops a little this engine will race. What is the cause of the trouble?

S. C.

You will probably find that the trouble is caused by faulty valve setting. See that the valves on both engines are set exactly alike; then block up both governors ¼ of an inch and, with the engines running slowly, adjust the knock-off rods until the valves on the head end unhook and those on the crank end just touch the knockoff block. This will give you very nearly equal cutoff on both ends of the cylinder for points between ¼ and ⅓ of the stroke. Any slight inequality can be corrected by the use of the indicator. Adjustment of the governor is just as much a part of valve setting on the Corliss engine as the adjustment of lap, lead and length of motion-plate connections, and if the governor is properly adjusted, when it is in its lowest position the engine will take steam very nearly full stroke, and when in its highest position the steam valves will not be opened at all.

Details for establishing in Ireland an electric plant to furnish current generated from peat gas, the first plant of its kind in Great Britain, were recently reported to a committee of the British House of Commons. Consul-General Robert J. Wynne, writing from London, says that the Dublin and Central Ireland Electric Power Company is seeking a franchise to supply electricity to portions of the counties of Dublin, Kildare, Queens and Kings, and have arranged to purchase 500 acres of peat bog in the district. The promoters of the new scheme intend to use the German process of peat preparation by which it is advantageous to retain 50 per cent. of the moisture in the peat.

Book Reviews

ELECTRICAL ENGINEERS' POCKET BOOK. By Horatio A. Foster. Published by D. Van Nostrand Company, New York, 1908. Leather; 1635 pages, 4x7 inches; numerous illustrations and tables. Price, $5.

This is the fifth edition of Mr. Foster's well-known compilation, and it shows the results of exhaustive revision. Every section of the book has been thoroughly revised and many of them entirely rewritten. While Mr. Foster's plan of having the different sections written or revised by engineers especially qualified by actual experience in their several lines has entailed great delay in the work of revising the fourth edition, the results obtained would seem to justify the delay. The present edition is far and away superior to the previous one. It is unnecessarily bulky, perhaps, by reason of undue elaboration in some sections, but this is preferable to skimpy treatment which leaves the user uncertain as to the application of formulas or rules to his particular case.

INTERNAL COMBUSTION ENGINES. By R. C. Carpenter and H. Diederichs. Published by D. Van Nostrand Company, New York, 1908. Cloth; 610 pages 6x9½ inches; numerous illustrations. Price, $5.

It is difficult to express a general opinion regarding this book because of the very uneven quality of it. In places it is admirable; in others disappointing in the extreme. However, one cannot expect perfection even in textbook authors. The work is largely compilation, and this has been done with the high degree of skill which would naturally be expected of these authors. It is regrettable, however, that more original work, for which Professors Carpenter and Diederichs have excellent opportunities and conspicuous ability, was not put in the book.

The English is very lax; thus, on page 2, "the space is equal to the mean velocity multiplied by the time." If "space" were used in the sense of "distance," or if the moving mass had unit area perpendicular to its path, this would be true, but as no area is specified and the "space" and volume swept out are both represented by the same symbol, the statement is, at best, incomplete. Again, on page 66: "It shows the highest efficiency which an *actual engine can* possibly realize if it follows exactly the theoretical cycle. Practically this can never be realized." The italics are ours.

When the authors get away from thermodynamic and physical fundamentals their statements are frequently questionable. Thus, on page 48: "The expanding products of combustion in a gas engine are composed of N, CO_2, H_2O and possibly a trace of NO; for this reason (*sic*) the value of $C_p \div C_v$ is often taken as 1.37." That is ingenious, but lamentably academic. Again, on page 100 it is stated that the "effect" of highest possible compression "is" greater mean effective pressure, lower terminal pressure and three other results. Just how high compression entails low-release pressure is rather obscure, especially in combination with higher mean effective pressure, which usually is one result of high compression. It is, of course, true that engines have been built which showed lower release pressure than other engines having lower compression, but not because of the difference in compression. Other things being properly treated, higher compression inevitably produces higher release pressure, within practical limits.

The descriptions of commercial types of engines and producers are amongst the best portions of the book. The presentation of fundamental principles is good, but adds nothing to the fund of knowledge previously established. The chapter on gas-engine performance is more or less perfunctory, and the tables of results of engine and producer tests leave a great deal to be desired. The discussions of combustion, gas-engine fuels, fuel mixtures and regulation (governing) are excellent, although the illustrations in the chapter on regulation are mostly so poorly executed as to be worthless. The chapter on estimating the power of an engine is compilation and leaves the reader "up in the air." Six methods are cited, of which two are absurd and one empirical, but the authors were probably too polite to give the reader the benefit of that information.

The final chapter, on cost of installation and operation, is the most valuable one in the book; it will doubtless become obsolete in a relatively short time, however, because of the rapid progress that is being made in the direction of standardization and improvement of design and manufacturing methods.

Books Received

"Hydro-Electric Developments." By Preston Player. McGraw Publishing Company, New York. Cloth; 68 pages, 4½x7¼ inches; illustrated; indexed. Price, $1.

"The Slide Rule." By Charles N. Pickworth. Eleventh edition. Published by D. Van Nostrand Company, New York. Cloth; 113 pages, 5x7 inches; 29 illustrations. Price, $1.

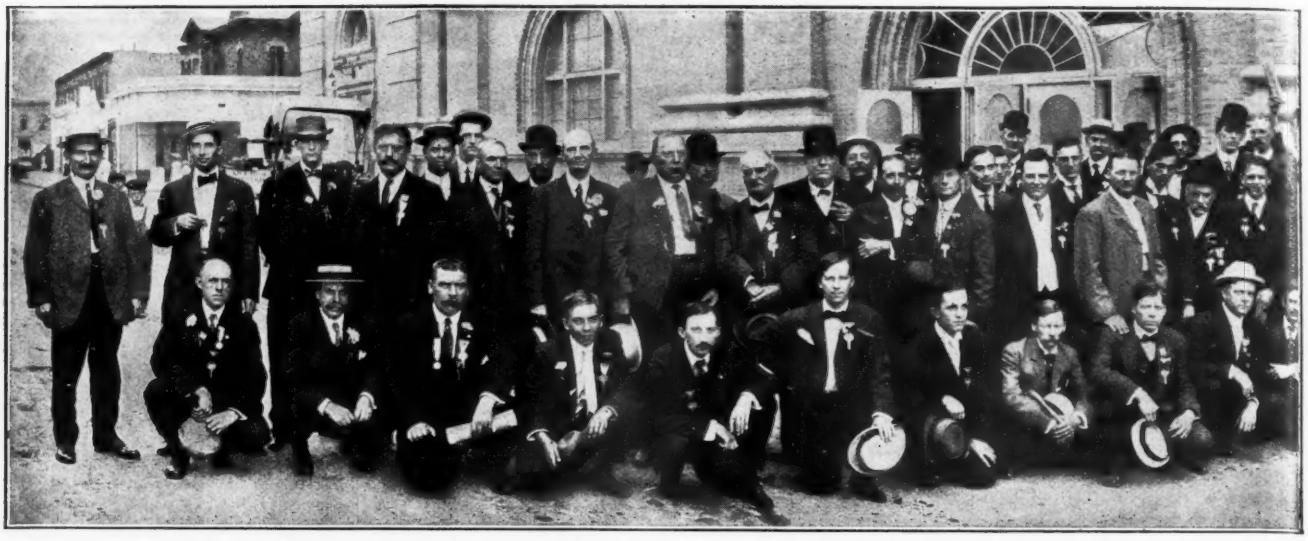
"Scientific Books," is the title of the new catalog issued by the Hill Publishing Company, of 505 Pearl street, New York, and 6 Bouverie street, London. This is one of the most complete book catalogs ever published and lists nearly if not quite every work in any way treating upon the industries and sciences represented in the field covered by *The Engineering and Mining Journal*, POWER AND THE ENGINEER and the *American Machinist*, and much besides. Among the works listed will be found those treating upon water, wiring and wireless telegraphy; turbines, transformers and toolmaking; stones, steel and steam engines; pumps, prospecting and power plants; motors, mining law and mill work; lubrication, lead and lathe practice; iron, induction coils and indicators; gold, geology and gas engines; furnaces, fuel and field engineering; dynamos, drawing and determinative mineralogy; copper, clay and chemistry, boilers, bells and batteries; automobiles, assaying and alternating currents. All these subjects and hundreds of others that the scientific or practical man is interested in will be found in the table of contents. One feature of this list of books that makes it particularly valuable is the fact that the date of publication of every work from the pens of more than 1300 different authors is given, showing how recently the work was put upon the market. The catalog is completely indexed, both as to subjects and authors, and will be sent on request.

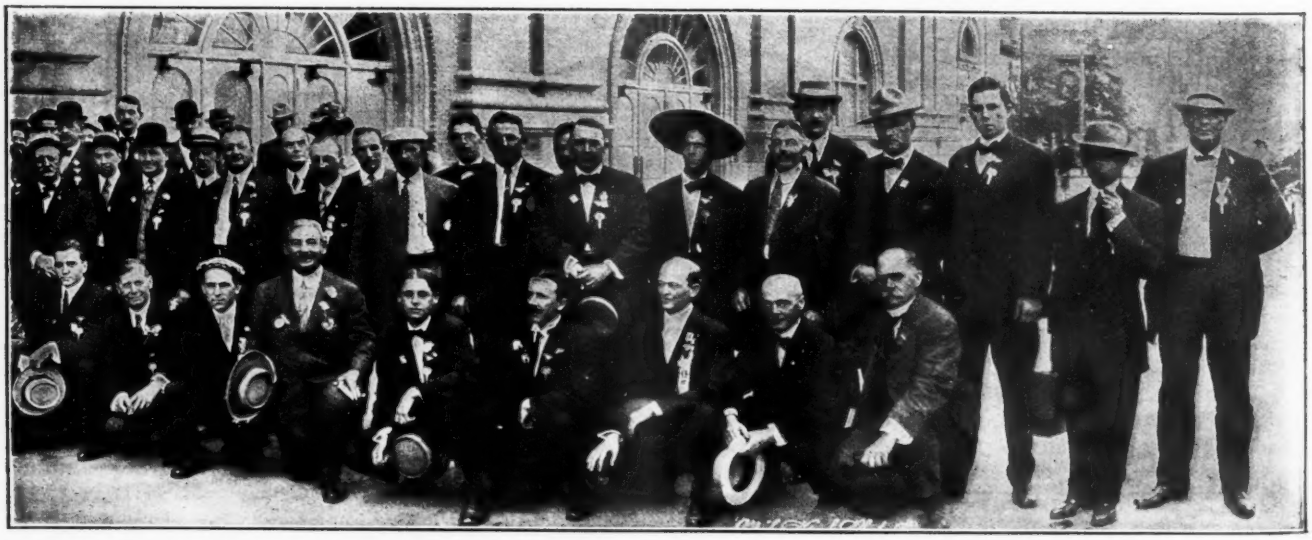
The seventeenth annual (1908) edition of "Hendricks' Commercial Register of the United States," for buyers and sellers, is out. By comparing the present with past editions it is seen that the publisher, the S. E. Hendricks Company, New York, continues to improve and add to each issue. The 1907 edition required 76 pages to index its contents, while the present edition requires 82 pages. As each page contains 412 classifications, the six additional pages contain 2472 additional trade classifications, making for the 82 pages a grand total of 33,684 headings, each of which represents the manufacturers, etc., of some machine, tool, apparatus, specialty or material. The first edition was issued in 1891 and contained about 500 pages, while the present numbers more than 1,300 pages and contains upward of 350,000 names and addresses classified under 33,684 trade headings. It is expressed to any part of the United States on receipt of $10.

Personal

Thomas H. Allen, formerly with the Allis-Chalmers Company, has been appointed general manager of the foundry and machine department of the Livermore Foundry and Machine Company, Memphis, Tenn.

Francis W. Hoadley has been elected secretary and treasurer of the Cassier Magazine Company. Mr. Hoadley has been prominently identified with the American Society of Mechanical Engineers and latterly with the Machinery Club of New York.





REPRESENTATIVES OF THE EXHIBITORS AT THE N. A. S. E. CONVENTION AT DENVER, COLO., SEPTEMBER, 1908

Convention of International Union of Steam Engineers

The first biennial convention and eleventh session of the International Union of Steam Engineers was held at Philadelphia during the week of September 14, the Continental hotel being the headquarters. There were in attendance about 150 delegates. While there was nothing particularly new, considerable business of importance to the members was transacted.

The entertainment features included a reception and ball, automobile rides to places of interest about the city, a visit to Atlantic City, as guests of the local association at that place, and a smoker.

The following officers were elected: President, Matt Commerford; secretary-treasurer, R. A. McKee; first vice-president, A. M. Huddell; second vice-president, A. J. Skiffington; third vice-president, M. Snellings; fourth vice-president, T. J. Roberts; fifth vice-president, M. Kelly; trustees, George F. Allen (chairman), R. G. Moser, C. E. Streevifg; delegates to A. F. of L., P. C. Winn, M. Murphy.

The next convention will be held at Denver, Colo., in 1910.

In connection with the convention an exhibition of power-plant supplies was held in a large store opposite the headquarters hotel, and the following firms had booths:

Anderson & Gaylord, of Philadelphia, who are agents for Atwood & Morrill, Salem, Mass.; the Direct Separator Company, Syracuse, N. Y., and the DuBois Iron Works, DuBois, Penn. Represented by F. C. Anderson, H. B. Gaylord and F. W. Lockwood.

Berry Engineering Company, Chester, Penn. Represented by W. I. Maude and J. J. Buckley.

Borgner Company, Cyrus, Philadelphia. Represented by C. A. Dickel.

Botfield & Co., A. B., Philadelphia. Represented by J. A. Reagan.

Brogan & Co., Philadelphia, who are agents for Elastic Metallic Packing Company, Philadelphia, Homestead Valve Manufacturing Company, Pittsburg; Kieley & Mueller, New York, and the Nelson Valve Company, Philadelphia. Represented by F. Powderly.

Burchfield Company, T. T., Philadelphia, who are agents for the Brownell Company, Dayton, O.; Gardner Governor Company, Quincy, Ill.; A. L. Ide & Sons, Springfield, Ill.; Whitlock Coil Pipe Company, Hartford, Conn. Represented by G. R. Chambers.

Burgmann, Feodor, Philadelphia. Represented by R. H. Molendo.

Cancos Manufacturing Company, Philadelphia. Represented by G. M. Costello, president, and S. M. Best.

Chapman Valve Manufacturing Company, Indian Orchard, Mass. Represented by G. B. Atkinson, C. F. Chaundy and L. J. Burby.

Cook's Sons, Adam, New York. Represented by G. E. Tanberg.

Crane Company, Chicago, Ill. Represented by E. C. Sabin, T. H. Russell and E. I. Concannon.

Daley & Davis, Philadelphia, agents for the American Boiler Flue Cleaner Company, Trenton, N. J. Represented by W. A. Daley and M. R. Davis.

Dearborn Drug and Chemical Works, Chicago, Ill. Represented by G. F. Duemler, J. Hammell and H. A. Phillips.

De Zouche, Hanson & Co., Philadelphia, agents for Bowers Rubber Works, San Francisco, Cal. Represented by J. De Zouche, E. Hanson and J. G. Roberts.

Findlay Company, A. W., Philadelphia. Represented by W. M. Moore.

Garlock Packing Company, Palmyra, N. Y. Represented by H. Edwards and A. Smith.

Harrison Safety Boiler Works, Philadelphia. Represented by J. R. Hibbs and R. D. B. Wright.

Hewes & Phillips Iron Works, Newark, N. J. Represented by R. M. Phillips and C. E. Demarest.

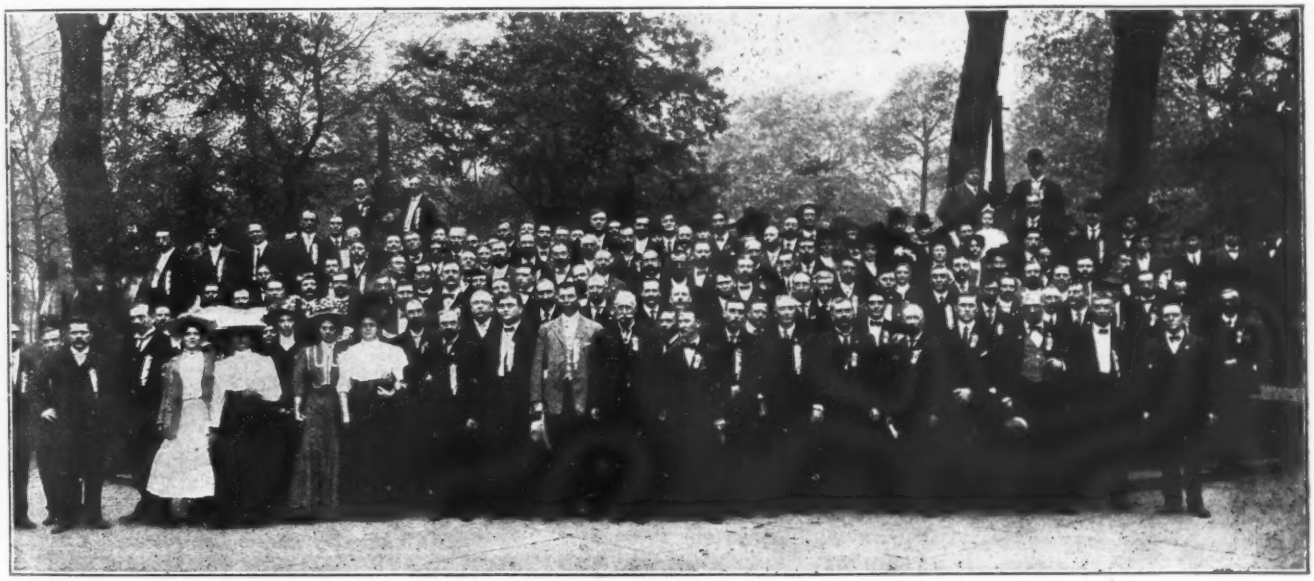
Home Rubber Company, Trenton, N. J. Represented by E. Bainbridge, W. G. Bergen and Dick Foley.

Houghton & Co., E. F., Philadelphia. Represented by Franklin Moore, G. Pressell and H. Barry.

Jenkins Bros., New York. Represented by J. C. McHughe, S. Laird and J. G. Smeltz.

Johns-Manville Company, H. W., New York. Represented by S. R. Fitch, T. B. Stein, T. J. S. Nicely and D. K. Bickson.

Keystone Chemical Manufacturing Company, Philadelphia. Represented by W. H. Brey.



DELEGATES AND FRIENDS AT THE CONVENTION OF THE INTERNATIONAL UNION OF STEAM ENGINEERS AT PHILADELPHIA, 1908

Keystone Lubricating Company, Philadelphia. Represented by H. A. Buzby, C. A. Hopper, L. F. Hopper and L. B. Carpenter.

Ladew, Estate of Edward R., New York. Represented by F. W. Craighead.

Livezey, John R., Philadelphia, agent for Armstrong Cork Company, Pittsburg, Norristown Magnesia and Asbestos Company, Norristown, Penn. Represented by Clifford P. Williams and H. Souder.

Lonergan & Co., J. E., Philadelphia. Represented by A. F. Montague.

Lord Company, George W., Philadelphia. Represented by Capt. J. E. Doughty, C. W. Philips, B. L. Lord and R. Downs.

Manning, Maxwell & Moore, New York, including the exhibits of the Ashcroft Manufacturing Company, the Consolidated Safety Valve Company, the Hancock Inspirator Company and the Hayden Derby Manufacturing Company. Represented by C. Monroe Smith.

Newhall Engineering Company, George

M., Philadelphia. Represented by G. B. Smith.

New York and New Jersey Lubricant Company, New York. Represented by C. F. Pierce.

Peerless Rubber Manufacturing Company, New York. Represented by P. G. Staunton.

Pennsylvania Petroleum Company, Philadelphia.

Pennsylvania Flexible Metallic Tubing Company, Philadelphia. Represented by E. Hines, W. Willis and J. M. Odenheimer.

Philadelphia Lubricator and Manufacturing Company, Philadelphia. Represented by L. T. Mattes and J. F. Lewis.

Powell Company, William, Cincinnati. Represented by H. T. Heath of G. J. Rainer & Co., agents.

POWER AND THE ENGINEER, New York. Represented by C. W. Dibble, L. G. Vogel, Jack Armour, H. K. Fisher, E. T. Binns, E. Byrne and B. Weiting.

Restein Company, Clement, Philadelphia. Represented by J. Sulger and N. Miller.

Sarco Fuel Saving and Engineering Company, New York. Represented by W. A. Darrow.

Sayen, Osgood, Philadelphia. Represented by O. Sayen and J. Pleasant.

Schieren Company, Charles A., New York. Represented by H. Sommers and J. Neely.

Schutte & Koerting Company, Philadelphia. Represented by J. J. Gessleman and J. J. Forman.

Special Equipment Manufacturing Company, New York. Represented by J. V. Parks.

Templeton Manufacturing Company, Boston, Mass. Represented by J. A. Coutts, of W. D. Garrett & Co., agents.

Underwood & Co., H. B., Philadelphia. Represented by E. Crawford, E. J. Rooksby, C. O. Ralph and D. W. Pedrick.

Watson & McDaniel Company, Philadelphia. Represented by F. L. Jahn.

Webster & Co., Warren, Camden, N. J. Represented by E. K. Lanning and J. Montgomery.

Williams & Co., J. H., Brooklyn, N. Y.

Wilpaco Packing Company, New York. Represented by G. M. A. Haas and W. F. Robertson.

Winfield, A. C., Brooklyn, N. Y. Represented by G. Bollmann, J. Engassen and G. Riedler.

Wing Manufacturing Company, L. J., New York. Represented by H. S. Wheeler.

Zurn Company, The O. F., Philadelphia. Represented by B. Haines, L. Douges and G. W. Childs.

When the whole blame world seems gone to pot, and business is on the bum, a two-cent grin and a lifted chin helps some, my boy, helps some.—A Cheerful Spirit, in *Electric Traction Weekly.*

Business Items

The Riverside Engine Company has extended its sales organization by the opening of an office at 49 North Seventh street, Philadelphia, Penn., in charge of W. P. Dallett.

Anderson & Gaylord, 1107 Real Estate Trust building, Philadelphia, have been appointed agents in that territory for the Blake Pump and Condenser Company, Fitchburg, Mass.

The American Huhn Metallic Packing Company, 1876 Broadway, New York City, has purchased the patent rights for the United States of the Bach metallic packing rings, which were described in the September 22 number of POWER AND THE ENGINEER.

John S. Hofner, superintendent of the Lucas County Infirmary, Toledo, Ohio, says that the three Buckeye boiler skimmers used in their boilers have given entire satisfaction; in fact far beyond his expectation. After a severe test for sixty days he has recommended their adoption for all the boilers in the plant. These skimmers were furnished by the Buckeye Boiler Skimmer Company, South End, Toledo, Ohio.

We have received from the Vandyck Churchill Company, 91 Liberty street, New York, a brass paper clip which is ideal for holding loose papers or letters together at the top, or side, as the case may be. The clip, which is 2½x2½ inches, is ornamented with a view of a 4-feed Richardson automatic sight-feed oil pump, to serve as a "reminder" that this company handles the Sight Feed Oil Pump Company's specialties, as well as other lubricating systems.

The rolling mill being built at Girard, Ohio by the A. M. Byers Company, of Pittsburg, is expected to be in operation by the first of the year, employing 800 men. The skelp mills will be driven by two engines now being built by the Wisconsin Engine Company, of Corliss, Wis., one 26x36 heavy-duty type, the shaft of which carries a rope wheel and is also direct-connected to the mill shaft. The other engine is a 28x54 simple heavy-duty, with its shaft extended to take a coupling connecting it to the mill. The contract calls for the delivery of these engines forty-five days from September 3.

The Monarch Steam Blower Company, of Troy, N. Y., manufacturer of the "Monarch" steam flue blower and "Sterling" metallic packing, has removed to larger quarters at 187 River street, that city. They will occupy the entire building extending from River street through to Front street, and have purchased considerable new equipment for the manufacture of their product. This change of location is due to the increased demand for rear-end flue blowers and to their "Sterling" metallic packing business, which they recently absorbed and which was formerly conducted by Germain Hogan, of Troy.

New Equipment

N. T. and C. H. Conn, Franklin, Ky., will establish a 20-ton ice plant.

City of Luverne, Ala., has voted bonds for constructing water works.

City of Antlers, Okla., contemplates installing an electric-light plant.

The city of Christiansburg, Va., has voted $25,000 bonds for water works.

The Unity Cotton Mills, La Grange, Ga., will erect a new mill to cost over $400,000.

Parker, Webb & Co., Detroit, Mich., will erect a new packing and storage house.

The Idaho-Oregon Light and Power Company will erect a sub-station at Emmett, Idaho.

The Benson Lumber Company, San Diego, Cal., is planning to install an electric plant.

The Viroqua (Wis.) Electric Light Company, it is said, will rebuild its plant on a larger scale.

The city of Marceline, Mo., contemplates establishing water works. B. B. Putnam, mayor.

J. Tyson, Rio Grande, Texas, will erect a pumping plant for furnishing the city with water.

The city of Chelsea, Okla., contemplates issuing bonds for the installation of water system.

The Consumers Heat, Light and Power Company, Belington, W. Va., will construct water works.

The city of Ennis, Texas, will vote on issuing $13,000 bonds for the construction of water works.

It is reported that the German Brewing Company, Hagerstown, Md., will erect a cold-storage plant.

Plans are being prepared by the Ontario Knitting Company, Oswego, N. Y., for a five-story factroy.

The Charlottesville (Va.) & Albermarle Railway Company is planning to increase the output of its power house.

The town of Wake Forest, N. C., will vote on the question of issuing $10,000 bonds to build an electric plant.

City of Oakland, Md., will open bids October 19 for water-works and sewerage system. Truman West, mayor.

The city of Augusta, Ga., contemplates installing an auxiliary steam pump at a cost of over $60,000.

Fire at the plant of the Iron River (Wis.) Water, Light and Power Company ruined much of the machinery.

The Aberdeen (S. D.) Light and Power Company has been granted franchise to establish an electric-light plant.

Plans have been completed by the Barboursville (Ky.) Water Works Company for a water-works system.

The City Council of Quanah, Texas, has decided to have plans and specifications for water works prepared.

The City Council, of Douglas, Wyo., is said to have under consideration the question of municipal water works.

The City of St. Henry, Ohio, will vote on the question of constructing water works. Wm. H. Romer, city clerk.

Plans have been prepared for two power houses at Newton Falls, Ohio, for the Peerless Electric Company, of Warren, Ohio.

City of Marietta, Ga., will vote for issuance of $80,000 bonds for construction of water works. W. J. Black, clerk.

Plans are being prepared for a power house for the Kansas-Colorado Electrical Transmission Company, at Garden City, Mo.

The National Capital Brewing Company, Washington, D. C., has awarded contract for the erection of a two-story ice plant.

It is reported that the Shelby (N. C.) Cotton Mills is having plans prepared for an additional building. Electric power will be used.

The County Commissioners, Shelbyville, Ind., have under consideration the question of installing an electric plant in the county jail.

It is said that the Tennessee Coal, Iron and Railroad Company, of Birmingham, Ala., will establish water supply for Ensley, Ala.

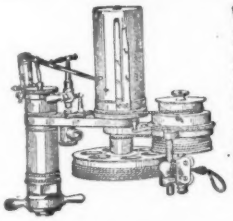
John Hoyer has applied to the City Council of Corliss, Wis., for franchise to install and operate an electric-light plant and water-works.

Robert E. Cavette, of Spokane, Wash., has

SH! **HARDLY A SOUND**

can be heard where New Process Rawhide pinions are used. There's no *ring* to rawhide. Our plant is the only one in the world manufacturing Rawhide for gears only.

NEW PROCESS RAW HIDE COMPANY,
SYRACUSE, NEW YORK.



WHAT! NO INDICATOR?

Don't you know that I can give you a fine up-to-date outfit, new, from $25 00 up, and that I will let you pay a part of it acting as my agent in your spare time?

I will give you a thorough course of indicator instruction with a fine indicator to practice with for $5 00 per mo. Catalog ?

Extra ¼ in Area Cyl. for Ammonia, Gas Engine and high pressure work.

A. C. LIPPINCOTT, Newark, N. J.

THE BRISTOL COMPANY
MANUFACTURERS OF
BRISTOL'S RECORDING PRESSURE
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VACUUM GAUGES
AND

a complete line of recording instruments for pressure, temperature and electricity.

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Waterbury, Conn.

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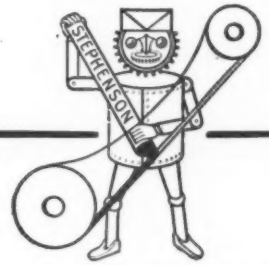


THE AFTER EFFECTS ARE PLEASANT

Don't waste good belts and lose valuable power. **STEPHENSON Bar Belt Dressings** contain no Rosin nor any other ingredients injurious to Belting. Our **RED Label** and **GREEN Label Brands** are two entirely different and distinct preparations. No one kind of Dressing is good for all Belts—you know that. **STEPHENSON Dressing** not only prevents slipping and gives full speed from slack belts, but **the after effects are pleasant**—it KEEPS those belts in good condition and greatly prolongs their life.

This means a saving in BELTING, which is an important item when figuring the year's expenses.

RED Label Brand for Leather belts;
GREEN Label for Rubber and Canvas.

Your protection against substitution is **The Man with the Cog-Wheel Face** on each Pound Stick.

Of Dealers everywhere, or

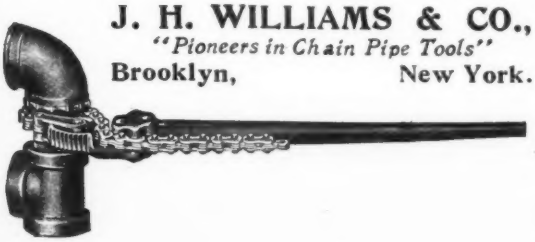
STEPHENSON MFG. CO.
ALBANY, N. Y.

Discarded Features

See (dotted-line) chain.

Frequently you or your man is on a scaffold or platform and working on pipe directly overhead. See that you are using "Agrippa" principles when in this position or you will invite grave dangers. We discarded the "one-side-chain-fastening" years ago because it was a dangerously unsafe one. Chain swung in the center as is the Agrippa permits absolutely safe locking operation and Agrippas give you further advantages in that you are able to adjust all sorts of fittings with small or irregular surfaces and everything in pipe line. Fully guaranteed and free trial from all dealers.

J. H. WILLIAMS & CO.,
"Pioneers in Chain Pipe Tools"
Brooklyn, New York.



The World's Best Pulley

is without question the Phillips Pressed Steel Pulley. It insures greater durability, speed and safety. 'Tis ideal in construction. Trial allowed before purchase.

Philips Pressed Steel Pulley Works,
4th and Glenwood Aves., Philadelphia, Pa.

CAN YOU TURN A KEY?

If so, then you can operate a Mason Reducing Valve. Turn it to any desired pressure and slip the key on your key-chain. The "Mason" will be tamper-proof. Write!

The Mason Regulator Co., Boston, Mass.

FOR SALE BY ALL SUPPLY HOUSES

50 CTS. PER STICK, $5.00 PER DOZEN

It is the only article that will prevent sparking. Will keep the Commutator in good condition and prevent cutting. Absolutely will not gum the brushes.

It will put that high gloss on the Commutator you have so long sought.

K. McLennan & Co., Sole Manufacturers
411-130 Dearborn St., Chicago, Ill.

been granted a franchise to establish a light water and cold-storage plant at Sunnyside.

The city of Athens, Ga., will spend about $70,000 in extending sewer and water-works. J. W. Barnett, city engineer, will supervise work.

The Alabama White Marble Company, Gantts Quary, Ala., will install additional equipment, including 300 horsepower engine, boilers, dynamo, etc.

New Catalogs

The Freestone Compound Company, Oak Lane, Philadelphia, Penn. Circular. Freestone boiler compound.

Henry Vogt Machine Company, Louisville, Ky. Catalog. Water tube boiler. Illustrated, 80 pages, 6x9 inches.

The Lucas Pump Company, Dayton, Ohio. Catalog No. 8. Power pumps. Illustrated, 30 pages, 3½x6 inches.

The Maxim Company, 130 Fulton street, New York. Catalog. Water tube boilers. Illustrated, 8 pages, 6x9 inches.

The Gas Power Producing Company, Lima, Ohio. Catalog. Lima gas engines. Illustrated, 34 pages, 6x9 inches.

Detroit Stoker and Foundry Company, Detroit, Mich. Catalog. Automatic stokers. Illustrated, 48 pages, 6x9 inches.

Abenaque Machine Works, Westminster Station, Vt. Catalog. Gasolene traction engines. Illustrated, 8 pages, 6x9 inches.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED—Representatives in each town to handle an entirely new line of steam specialties. Address "M," Perth Amboy, N. J.

WANTED—Thoroughly competent packing salesmen. The Henry Johnson Co., 175-187 Gates Ave., Jersey City, N. J.

WANTED—Engineer, a sober, industrious man familiar with engines, boilers and generators in 2500 h.p. plant. Good references required. The Helderberg Cement Co., Howes Cave, N. Y.

CHIEF ENGINEER, for industrial plant. Will have charge of Corliss engines, B. & W. boilers, d.c. generators, water purification plant and pipe lines throughout the plant. State age and experience. Address "Industrial Plant," POWER.

WE WANT LIVE SALESMEN CARRYING BELTING or engineers' supplies to sell established specialties as side line. Liberal commission. Address, giving present line and territory, The Warren Co., Inc., 491 Wells St., Chicago.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

CHIEF ENGINEER of large industrial plant desires change; active and alive, an expert with indicators and testing apparatus, can keep operating expenses at proper figures. Box 27, POWER.

WITH SEVEN YEARS' experience from shop to electrical engineer in charge of machinery and equipment of a railway light and power system, graduate mechanical engineer desires change. Box 40, POWER.

POSITION WANTED as chief engineer; experienced with all kinds of engines, steam turbines, a.c. and d.c. generators, motors and switchboards, boilers and pumps; I can get results and furnish the references; have been seventeen years in the mechanical and engineering business. Box 9, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

STIRLING BOILER TUBES, cracking off can stop at once or no pay. Wm. Fulton Engineering Co., office, 28 N. Canal St., Dayton, Ohio.

ALL PRACTICAL ENGINEERS should apply to Wm. O. Webber, Consulting Engineer, 432 Exchange Bldg., Boston, for information concerning tables on all engineering subjects.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

IF YOU DESIRE to learn the latest improvement in steam boilers, correspond with the Detroit Water Tube Boiler Co., Detroit.

ENGINES AND BOILERS, ½ to 2 h.p., engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make an investigation and report if patent can be had, and exact cost.

ENGINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass Avenue, St. Louis, Mo.

ENGINEERS, firemen, electricians, machinists, etc. New 25-page pamphlet containing questions asked by the examining boards sent free upon request. Geo. A. Zeller Book Co., 4468 W. Belle Place, St. Louis, Mo. Established 1870.

NEW BRITISH PATENTS ACT. A manufacturing firm possessing extensive and well equipped engineering works in the English Midlands invites inquiries from American firms desirous of arranging for the manufacture in England of patented mechanical or electrical specialties to comply with the requirements of the above Act now in force. Apply, in first instance to C. M. Stevenson, 29 Broadway, New York.

THE OWNER and manufacturer of one of the oldest and best known ice making and refrigerating machines desires to place the sale of same with reliable parties, who will handle it for a certain territory. Firms having refrigerating experience will be given preference and only those will be considered who are able to show both financial and engineering ability to successfully handle the machine. Box 46, POWER.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—Complete I. C. S. Steam Engineering Course. $25.00. Fred Ecksley, Tekamah, Neb.

FOR SALE—Electric light plant, growing town; 700 lights now in use. Price $6000.00. Reasons for selling, other business. Address Box 50, Giddings, Texas.

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A Flooded Wheel Pit can do no harm if your driving belt is a "Duxbak".

This is only one of the many cases that make it necessary to use Duxbak Waterproof Leather Belting, as you never know what may happen over night.

Duxbak Belting is not only waterproof, but [illegible] on account of its moisture-proof quality [illegible] more lasting and stronger puller than the ordinary kinds.

Send for a Duxbak Waterproof or Duxbak Steamproof belt, and remember it doesn't cost you one cent if it's not all we claim for it in our Duxbak Literature.

Get the literature anyway.

DUXBAK BELTING
TRADE MARK

Chas. A. Schieren Company
ESTABLISHED 1868.

**Tanners,
Belt Manufacturers**

69 CLIFF STREET, NEW YORK

Chicago, 84-86-88 Franklin St.
Pittsburg, 240 Third Ave.
Hamburg, Germany, Auf dem Sande 1.

Boston, 186-188 Lincoln St.
Denver, 1622 Wazee St.

Philadelphia, 226 North Third St.
Brooklyn, N. Y., 13th St. and 3rd Ave.
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National Tube Co., Pittsburg, Pa.

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Hewes & Phillips Iron Works, Newark, N. J.
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Murray Iron Works Co., Burlington, Iowa.
New Bedford Boiler & Mach. Co., New Bedford, Mass.
Parker Boiler Co., Philadelphia, Pa.
Rust Boiler Co., Pittsburg, Pa.
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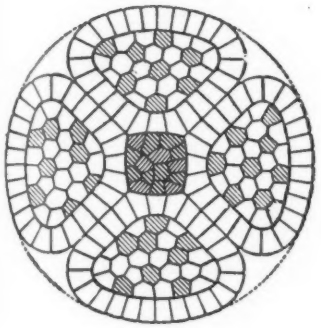

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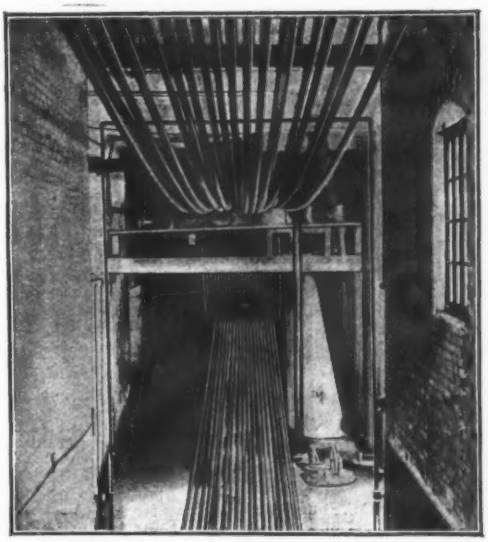

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Curtis & Curtis Co., Bridgeport, Conn

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Ohio Blower Co., Cleveland, O.

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Alberger Co., A. H., Buffalo, N. Y.
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Beggs & Co., James, New York.
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De La Vergne Mach. Co., New York.
Du Bois Iron Works, Du Bois, Pa.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
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Mesta Machine Co., Pittsburg, Pa.
Miller Improved Gas Engine Co., Springfield, O.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Otto Gas Engine Works, Philadelphia, Pa.
Struthers-Wells Co., Warren, Pa.
Westinghouse Mach. Co., Pittsburg, Pa.

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Du Bois Iron Works, Du Bois, Pa.

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Ball-Cooley Engr. Co., New York.

Engines, Steam
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Ball & Wood Co., Elizabethport, N. J.
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Buckeye Engine Co., Salem, O.
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Fitchburg Steam Engine Co., Fitchburg, Mass.
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Greenfield, Steam Engine Works, Harrison, N. J.
Griffith & Wedge Co., Zanesville, O.
Griscom-Spencer Co., New York.
Harrisburg Fdry. & Mach. Works, Harrisburg, Pa.
Harris Steam Engine Co., Wm., A., Providence, R. I.
Hewes & Phillips Iron Works, Newark, N. J.
McIntosh, Seymour & Co., Auburn, N. Y.
Mesta Machine Co., Pittsburg, Pa.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Morris Machine Works, Baldwinsville, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Providence Engr. Works, Providence, R. I.
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Rollins Engine Co., Nashua, N. H.
Russell Engine Co., Massillon, O.

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Vilter Mfg. Co., Milwaukee, Wis.
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York Mfg. Co., York, Pa.

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Loew Mfg. Co., Cleveland, O.
Ohio Blower Co., Cleveland, O.
Patterson & Co., Frank L., New York.
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Sims Co., Erie, Pa.
Sterling Blower & Pipe Mfg. Co., Hartford, Conn.
Sturtevant Co., B. F., Hyde Park, Mass.
Whitlock Coil Pipe Co., Hartford, Conn.
Wright Mfg. Co., Detroit, Mich.

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Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.

Fans, Electric
General Electric Co., Schenectady, N. Y.
Triumph Elec. Co., Cincinnati, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.
Wing Mfg. Co., L. J., New York.

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Buffalo Forge Co., Buffalo, N. Y.
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Green Fuel Economizer Co., Matteawan, N. Y.
Wing Mfg. Co., L. J., New York.

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Green Fuel Economizer Co., Matteawan, N. Y.
Griscom-Spencer Co., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Kewanee Boiler Co., Kewanee, Ill.
Loew Mfg. Co., Cleveland, O.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Murray Iron Works Co., Burlington, Iowa.
National Pipe Bending Co., New Haven, Conn.
Patterson & Co., Frank L., New York.
Robertson & Sons, Jas. L., New York,
Sims Co., Erie, Pa.
Stewart Heater Co., Buffalo, N. Y.
Tudor Boiler Mfg. Co., Cincinnati, O.
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Wheeler Condenser & Engineering Co., New York.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

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Strong, Carlisle & Hammond Co., Cleveland, Ohio.

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Ohio Blower Co., Cleveland, O.
Sterling Blower & Pipe Mfg. Co., Hartford, Conn.

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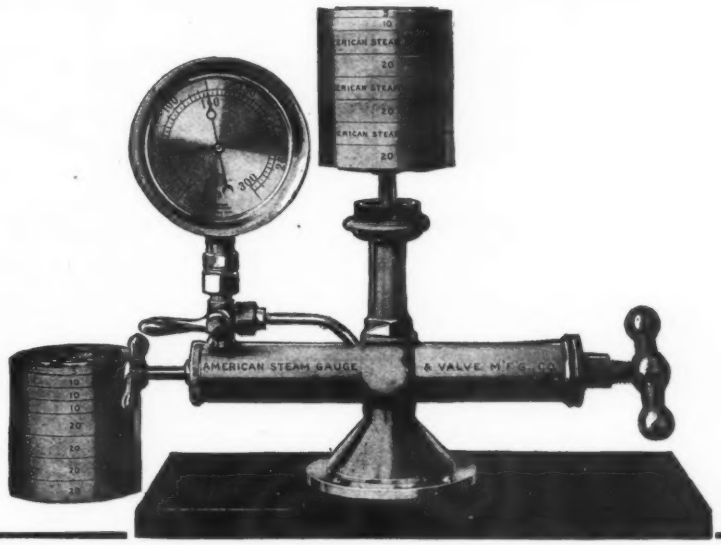
Eclipse Feed Water Heater & Purifier Co., Oshkosh, Wis.



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National Tube Co., Pittsburg, Pa.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Valve & Fittings Co., Barberton, Ohio.
Pittsburgh Valve, Foundry and Construction Co., Pittsburg, Pa.
Trimont Mfg. Co., Roxbury, Mass.

Flanges

Ball & Wood Co., Elizabethport, N. J.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Jefferson Union Co., Lexington, Mass.

Flanges, Forged Steel

American Spiral Pipe Works, Chicago, Ill.

Floats

Anderson Co., V. D., Cleveland, Ohio.
Hercules Float Works, Springfield, Mass.
Reliance Gauge Column Co., Cleveland, Ohio.

Floor Stands

Chapman Valve Mfg. Co., Indian Orchard, Mass.

Forges

Buffalo Forge Co., Buffalo, N. Y.
Wing Mfg. Co., L. J., New York.

Forgings, Drop

Williams & Co., J. H., Brooklyn, N. Y.

Forgings, Iron and Steel

Griscom-Spencer Co., New York.

Furnace Tile

C-O-Two Furnace Co., Syracuse, N. Y.

Furnaces, Annealing

Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Forging

Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Hardening

Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Melting

Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Smokeless

McClave-Brooks Co., Scranton, Pa.
Murphy Iron Works, Detroit, Mich.
Wilkinson Mfg. Co., Bridgeport, Pa.

Furnaces, Tempering

Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Gage Glasses

Chesterton & Co., A. W., Boston, Mass.
Garlock Packing Co., Palmyra, N. Y.
Johnson Co., Henry, Jersey City, N. J.
Peerless Rubber Mfg. Co., New York.

Gage Glasses—*Continued.*

Quaker City Rubber Co., Philadelphia, Pa.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Sterling Lubricator Co., Rochester, N. Y.
Webster & Co., Warren, Camden, N. J.

Gage Testing Outfit

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Gages, Ammonia

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Gages, Draft

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Gages, Pressure

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Webster & Co., Warren, Camden, N. J.
Williams Valve Co., D. T., Cincinnati, Ohio.

Gages, Recording

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Ohio Injector Co., Wadsworth, Ohio.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Gages, Vacuum

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Gages, Water

Automatic Safety Water Gauge Co., Muskegon, Mich.
Greene, Tweed & Co., New York.
Huyette Co., Paul B., Philadelphia, Pa.
Jerguson Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Ohio Brass Co., Mansfield Ohio.
Reliable Water Gauge Co., St. Louis, Mo.
Reliance Gauge Column Co., Cleveland, O.
Wright Mfg. Co., Detroit, Mich.

Gaskets

American Goetze-Gasket & Packing Co., New York.
Anchor Packing Co., Philadelphia, Pa.
Carey Co., Philip, Cincinnati, O.
Detroit Leather Specialty Co., Detroit, Mich.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Keeler Co., E., Williamsport, Pa.
Mechanical Rubber Co., Cleveland, O.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

Gaskets, Copper

American Goetze-Gasket & Packing Co., New York.

Gaskets, Leather

Detroit Leather Specialty Co., Detroit, Mich.

Gaskets, Water Gage

Johnson Co., Henry, Jersey City, N. J.
Morse, R. F., Providence, R. I.

Gears

Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
New Process Raw Hide Co., Syracuse, N. Y.

Generating Sets

American Engine Co., Bound Brook, N. J.
C & C Electric Co., New York.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
Foos Gas Engine Co., Springfield, Ohio.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincinnati, Ohio.

Governors, Pump

American Boiler Economy Co., Philadelphia, Pa.
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Davis Co., John, Chicago, Ill.
Fisher Governor Co., Marshalltown, Iowa.
Gardner Governor & Separator Co., Quincy, Ill.
Mason Regulator Co., Boston, Mass.
Strong, Carlisle & Hammond Co., Cleveland, O.
Webster & Co., Warren, Camden, N. J.

Graphite

Carpenter & Co., W. D., New York.
Garlock Packing Co., Palmyra, N. Y.
Johnson Co., Henry, Jersey City, N. J.

Grates, Chain Traveling

Green Engineering Co., Chicago, Ill.

Grates, Clinker Cutting

McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.

Grates, Dumping

Beggs & Co., James, New York.
Martin Grate Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.
Thacher & Co., George H., Albany, N. Y.

Grates, Rocking

Martin Grate Co., Chicago, Ill.

Grates, Shaking

Martin Grate Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.
Robertson & Sons, Jas. L., New York.
Salamander Grate Bar Co., New York.
Thacher & Co., George H., Albany, N. Y.

Grates, Stationary

Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.

Grease

Cook's Sons, Adam, New York.
Dixon Crucible Co., Jos., Jersey City, N. J.
Harris Oil Co., A. W., Providence, R. I.
Kellogg & Co., E. H., New York.
Keystone Lubricating Co., Philadelphia, Pa.
N. Y. & N. J. Lubricant Co., New York.

Grease Extractors

Beggs & Co., James, New York.
Griscom-Spencer Co., New York.
Hussey, McCann & Co., New York.

Heating and Ventilating Systems

Buffalo Forge Co., Buffalo, N. Y.
Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.
Sturtevant Co., B. F., Hyde Park, Mass.
Webster & Co., Warren, Camden, N. J.
Wing Mfg. Co., L. J., New York.

Hoists

Northern Engineering Works, Detroit, Mich.

Hose

Anchor Packing Co., Philadelphia, Pa.
Bowers Rubber Works, San Francisco, Cal.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Lagonda Mfg. Co., Springfield, O.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
Myers & Bro., F. E., Ashland, O.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Phila., Pa.

Hose, Air

Diamond Rubber Co., Akron, Ohio.
Restein Co., Clement, Philadelphia, Pa.

Hose, Oil

Diamond Rubber Co., Akron, Ohio.
Restein Co., Clement, Philadelphia Pa.

Hose, Steam

Anchor Packing Co., Philadelphia, Pa.
Diamond Rubber Co., Akron, Ohio.
Restein Co., Clement, Philadelphia, Pa.

Hose, Water

Anchor Packing Co., Philadelphia Pa.
Diamond Rubber Co., Akron, Ohio.
Restein Co., Clement, Philadelphia, Pa.

Indicators, Gas Engine

American Steam Gauge & Valve Mfg. Co., Boston, Mass.

Indicators, Speed

Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Starrett Co., L. S., Athol, Mass.

Indicators, Steam Engine

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Lippincott Steam Specialty & Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Star Brass Mfg. Co., Boston, Mass.
Trill Indicator Co., Corry, Pa.

Injectors

American Injector Co., Detroit, Mich.
Detroit Lubricator Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.
Randle Machinery Co., Cincinnati, Ohio.
Robertson & Sons, Jas. L., New York.
Schutte & Koerting Co., Philadelphia, Pa.
Sherwood Mfg. Co., Buffalo, N. Y.

Inspection, Boiler

Fidelity & Casualty Co., New York.
Hartford Steam Boiler Insp. & Ins. Co., Hartford, Conn.

Insurance, Boiler

Fidelity & Casualty Co., New York.

Joints, Expansion

Alberger Condenser Co., New York.
Webster & Co., Warren, Camden, N. J.

Joints, Pipe

McCrea & Co., James, Chicago, Ill.

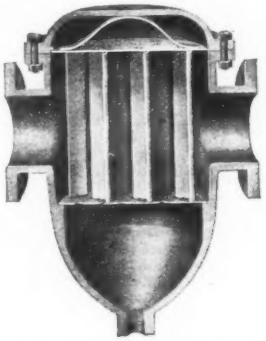
Websterizing

A Monthly Bulletin For Steam Engineers

VOL. I. OCTOBER, 1908. NO. 4.

The chief engineer of a power plant in Pennsylvania recently called on a brother engineer in the same town. He wanted to make a few comparisons.

Said he: "I want to know what



WEBSTER STANDARD HORIZONTAL OIL SEPARATOR

kind of results you're getting from your plant. We have the same boilers and engines, our water supply is the same, and I use as high grade coal as you do. My plant is not on a paying basis and I can't get it there. Now, are you in the same fix?"

"Not at all," replied his neighbor, "I'm getting excellent results—couldn't hope for better."

"Then what's the answer," asked the first, "what more can I do?"

"Is your plant 'Websterized?'"

"No, but my equipment is the best there is."

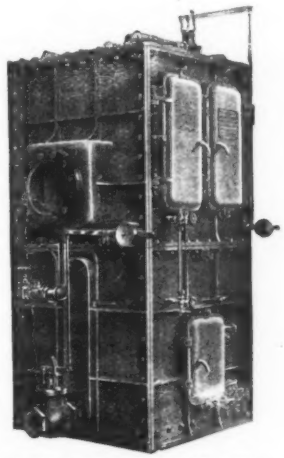
"Then that's the answer," said the successful engineer. "You can't get high efficiency or economy from engine, boiler, water supply and coal pile. They are the essential 'framework,' but it's the Webster Steam Specialties that 'fill in the chinks' and turn waste into saving by making the water healthy for the boilers, the engine free from hindrances, the coal pile's energy potent, and so on. You go home, 'Websterize' your plant, and see if your results aren't all right."

And the engineer went—and Websterized—and saw.

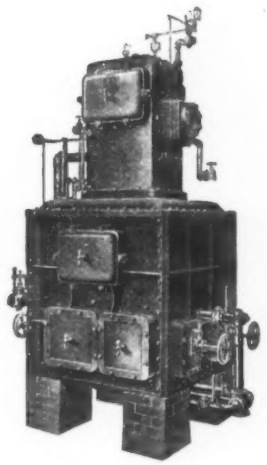
We make our Feed Water Heaters, Purifiers and Filters to suit individual conditions, after a careful analysis of the water they are to handle. No one Heater is right for *all* cases but we'll make a Webster that's right for *any* case. Ours are *not* thoroughfare Heaters. They use just enough exhaust steam to heat the water to the highest possible temperature.

For extreme conditions the Webster Chemical Purifier is particularly adapted. It treats the water *while it is hot* and insures a perfectly pure boiler feed.

The success of Webster Heaters is shown by the fact that, at the present



WEBSTER FEED WATER HEATER, PURIFIER AND FILTER



WEBSTER CHEMICAL PURIFIER.

time, there are 2,250,000 horsepower in use.

We also make Webster Steam and Oil Separators in many different styles for all usual or special purposes. Our long experience in the utilization of exhaust steam has enabled us to design and construct these devices in such a way that perfect satisfaction always follows their installation. Many thousands of them are in use in connection with the Webster System of Steam Circulation, which is well known as the most efficient method of utilizing exhaust steam for heating.

Let us send you, free, copies of Heater Booklet, 12-F; Chemical Purifier Booklet, 12-C; and Separator Booklet, 12-S.

If you are thinking of using exhaust steam for heating you will be interested in our new treatise on this subject—12-H—which describes a successful method of securing satisfaction and economy.

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Warren Webster & Co., Camden, N.J.

Joints, Rubber

Diamond Rubber Co., Akron, Ohio.

Kiln Equipment, Dry

Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.

Lace, Leather

Rhoads & Sons, J. E., Phila., Pa.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Lamps, Arc

General Electric Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Lamps, Incandescent

General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Lathes, Foot Power

Barnes Co., W. F. & John, Rockford, Ill.

Lubricants

Carpenter & Co., W. D., New York.
Cook's Sons, Adam, New York.
N. Y. & N. J. Lubricant Co., New York.

Lubricating and Oiling Devices

Lunkenheimer Co., Cincinnati, O.
Nugent & Co., W. W., Chicago, Ill.

Lubrication Engineer

Davis, Wm. M., Boston, Mass.

Lubricators

Chesterton & Co., A. W., Boston, Mass.
Cook's Sons, Adam, New York.
Detroit Lubricator Co., Detroit, Mich.
Greene, Tweed & Co., New York.
Griscom-Spencer Co., New York
Lunkenheimer Co., Cincinnati, O.
Manzel Bros. Co., Buffalo, N. Y.
Michigan Lubricator Co., Detroit, Mich.
Ohio Injector Co., Wadsworth, O.
Robertson & Sons, Jas. L., New York.
Sherwood Mfg. Co., Buffalo, N. Y.
Sight Feed Oil Pump Co., Milwaukee, Wis.
Stephenson Mfg. Co., Albany, N. Y.
Sterling Lubricator Co., Rochester, N. Y.

Machinery, Cement

Power & Mining Machinery Co., Cudahy, Wis.

Machinery, Coal and Ash Handling

Bartlett & Snow Co., Cleveland, Ohio.
Jeffrey Mfg. Co., Columbus, O.
Northern Engineering Works, Detroit, Mich.

Machinery, Conveying

Bartlett & Snow Co., Cleveland, Ohio.

Machinery, Refrigerating

De La Vergne Machine Co., New York.
Vilter Mfg. Co., Milwaukee, Wis.
Vogt Machine Co., Henry, Louisville, Ky.
York Mfg. Co., York, Pa.

Machinery, Second Hand

Hewes & Phillips Iron Works, Newark, N. J.
Randle Machinery Co., Cincinnati, Ohio.
Wickes Bros., Saginaw, Mich.

Machinery, Smelting and Mining

Moore & Co., Chas. C., San Francisco, Cal.

Machines, Blue Print

Buckeye Engine Co., Salem, O.

Machines, Crank Pin Turning

Underwood & Co., H. B., Philadelphia, Pa.

Machines, Ice

Vilter Mfg. Co., Milwaukee, Wis.

Machines, Milling, Portable

Underwood & Co., H. B., Philadelphia, Pa.

Machines, Pipe Cutting and Threading

Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Crane Co., Chicago, Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Toledo Pipe Threading Machine Co., Toledo, Ohio.
Trimont Mfg. Co., Roxbury, Mass.

Machines, Reseating, Flue Cap

Lagonda Mfg. Co., Springfield, O.
Leavitt Machine Co., Orange, Mass.
Liberty Mfg. Co., Pittsburg, Pa.

Machines, Reseating Valve

Leavitt Machine Co., Orange, Mass.

Machines, Valve Seat Planing

Underwood & Co., H. B., Philadelphia, Pa.

Machinists, General

American & British Mfg. Co., Providence, R. I.
Bruce-Meriam-Abbott Co., Cleveland, O.
Mathews, Hugh, Kansas City, Mo.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Providence Engineering Works, Providence, R. I.

Mats and Matting

Diamond Rubber Co., Akron, Ohio.
Home Rubber Co., Trenton, N. J.
Mercer Rubber Co., Hamilton Square, N. J.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.

Metal, Anti-friction

Allan & Son, A., New York.

Metal, Bearing

Allan & Son, A., New York.
Phosphor Bronze Smelting Co., Ltd., Philadelphia, Pa.

Meters, Steam

St. John, G. C., New York.

Micrometers

Starrett Co., L. S., Athol, Mass.

Mill Supplies

Quaker City Rubber Co., Philadelphia, Pa.

Motors and Dynamos

American Engine Co., Bound Brook, N. J.
C & C Electric Co., New York.
Clark Bros. Co., Belmont, N. Y.
General Elec. Co., Schenectady, N.Y.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Stow Mfg. Co., Binghamton, N. Y.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Elec. Co., Cincinnati, Ohio.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Motors, Water

Lagonda Mfg. Co., Springfield, O.

Nipples

National Tube Co., Pittsburg, Pa.

Oil and Grease Cups

American Injector Co., Detroit, Mich.
Cook's Sons, Adam, New York.
Griscom-Spencer Co., New York.
Keystone Lubricating Co., Philadelphia, Pa.
Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, O.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Sherwood Mfg. Co., Buffalo, N. Y.
Williams Valve Co., D. T., Cincinnati, Ohio.

Oil Burners

Hammel Oil Burner Co., Los Angeles, Cal.

Oil Dash Pots

Lammert & Mann, Chicago, Ill.

Oil Reservoirs

Burt Mfg. Co., Akron, O.

Oilers, Crank Pin

Penberthy Injector Co., Detroit, Mich.

Oiling Systems

Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Oils

Cook's Sons, Adam, New York.
Dearborn Drug & Chemical Wks., Chicago, Ill.
Harris Oil Co., A. W., Providence, R. I.
Kellogg & Co., E. H., New York.
New York & New Jersey Lubricant Co., New York.

Oils, Non-fluid

N. Y. & N. J. Lubricant Co., New York.

Packing, Asbestos

Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
Restein Co., Clement, Philadelphia, Pa.

Packing, Flange

Carey Co., Philip, Cincinnati, O.
Chesterton Co., A. W., Boston, Mass.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Phila., Pa.
Robertson & Sons, Jas. L., New York.
Smooth-On Mfg. Co., Jersey City, N. J.

Packing, Hydraulic

Anchor Packing Co., Philadelphia, Pa.
Brandt, Randolph, New York.
Chesterton Co., A. W., Boston, Mass.
Detroit Leather Specialty Co., Detroit, Mich.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Robertson & Sons, Jas. L., New York.
Schieren Co., Chas. A., New York.

Packing, Metallic

American Huhn Metallic Packing Co., New York.
Anchor Packing Co., Philadelphia, Pa.
Bridgeport Metallic Packing Co., Bridgeport, Conn.
Garlock Packing Co., Palmyra, N. Y.
Houchin-Aiken Co., Brooklyn, N.Y.
Johnson Co., Henry, Jersey City, N. J.
Mercer Rubber Co., Hamilton Square, N. J.

Packing, Piston

American Steam Packing Co., Boston, Mass.
Anchor Packing Co., Philadelphia, Pa.

Packing, Piston—*Continued.*

Bowers Rubber Works, San Francisco, Cal.
Carey Co., Philip, Cincinnati, O.
Chesterton Co., A. W., Boston, Mass.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Robertson & Sons, Jas. L., New York.
Underwood & Co., H. B., Philadelphia, Pa.

Packing, Pneumatic

Detroit Leather Specialty Co., Detroit, Mich.
Mercer Rubber Co., Hamilton Square, N. J.

Packing, Pump Valve

Anchor Packing Co., Philadelphia, Pa.
Diamond Rubber Co., Akron, Ohio.
Home Rubber Co., Trenton, N. J.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

Packing, Rod

American Huhn Metallic Packing Co., New York.
Anchor Packing Co., Philadelphia, Pa.
Bowers Rubber Co., San Francisco, Cal.
Brandt, Randolph, New York.
Bridgeport Metallic Packing Co., Bridgeport, Conn.
Carey Co., Philip, Cincinnati, O.
Chesterton Co., A. W., Boston, Mass.
Diamond Rubber Co., Akron, Ohio.
Flower Steam Specialty Co., Walter L., St. Louis, Mo.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Robertson & Sons, Jas. L., New York.
Sayen, Osgood, Philadelphia, Pa.
Steel Mill Packing Co., Detroit, Mich.

Packing, Valve Stem

Diamond Rubber Co., Akron, Ohio.
Home Rubber Co., Trenton, N. J.
Mechanical Rubber Co., Cleveland, Ohio.
Mercer Rubber Co., Hamilton Square, N. J.
Quaker City Rubber Co., Philadelphia, Pa.

Pipe

Ball & Wood Co., Elizabethport, N. J.

Pipe, Riveted Steel

Minneapolis Steel & Mchy. Co., Minneapolis, Minn.

Pipe, Wrought

National Tube Co., Pittsburg, Pa.

Pipe Bending

Ball & Wood Co., Elizabethport, N. J.
National Pipe Bending Co., New Haven, Conn.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Pipe Clamp

Simplex Engineering Co., Philadelphia, Pa.

HIGH salaries in the engineering profession today go to the engineers who know how to buy. Did you ever think of that? Knowing how to buy, when you come to think of it, means far more than saving a penny or two here and there. In the large sense it means that the engineer has a clear idea of the vast improvements taking place in the steam field today. After that it follows that such an engineer is going to hunt out the best and not buy until he is sure that he has the best.

Trade journals in the steam field will help you wonderfully, if you will use them. Study their advertisements. Follow this up with writing to the advertisers for information and you will find that every advertiser will send catalogs, booklets, working drawings, estimates and complete information as may be required in each case. Your first step in learning how to buy, therefore, is to answer advertisements. The result will be a library of information, a library, by the way, which has been said to be the most valuable and up-to-date any technical man could have.

High salaried chiefs today were beginners and learners a few years ago and in almost every case they learned their business only through keeping in touch in this manner with the progressive manufacturers and advancing with them. Up-to-date plants are run by up-to-date men and an up-to-date man is one who looks into each proposition in the steam field in order to know his business.

To get a fair idea of this matter consider the following case: Let us suppose you are located in a neighborhood where the water supply causes great loss each year to the manufacturers who are compelled to use it. The loss keeps up, everyone growls but no one does anything.

If you were to send a gallon of this water to a chemist you would very probably have to pay a heavy charge for analysis, report, formula, etc. The work is difficult and technical, and such an analysis must be made before the first step toward correction can be made.

Right here you learn, however, that if you will send the water to us we will make analysis and report free of charge, and go into details from the engineering point of view as well as from the chemist's standpoint. You will receive from us a complete course of instructions in your case. You may buy from us or not, as you see fit, but every sensible man knows that if the water supply is properly corrected your plant will show a great improvement and a great economy and part of that saving will come to you in the shape of an increased salary, and furthermore, that the news of your success will travel and promotion will follow.

None of us succeeds alone. If we succeed with a case, part of the credit is sure to go to the engineer. That means more money for him and promotion.

Let us pull together therefore. You write to us and we will place our laboratories and information bureaus at your disposal.

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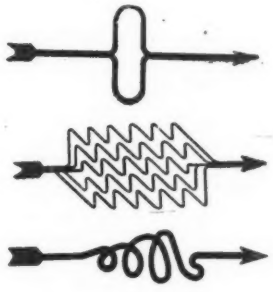
COCHRANE SEPARATORS

ABOUT BACK PRESSURE

The first diagram shows the steam path through a Cochrane Separator. The others show steam paths through competing separators.

Now, the question is, which arrangement creates the most back pressure? Back pressure in a separator can be due to two things, first, many turns, and, second, restricted passages. In the Cochrane Separator the number of turns has been reduced to the absolute minimum. That is, we turn the current of steam out of its path in order to let the particles of water or oil project themselves against a baffle, and then we have to turn the steam back into its path again. In other types, the steam is required to make a number of turns, simply because the designers did not know how the first turn should be made.



Now, as to the size of passages. Our arrangement of the steam path around the sides of the baffle gives us all the room we want, and we have made the passages so large that the pressure of the steam is not appreciably reduced. The friction loss through a Cochrane Separator is practically the same as through a globe valve of the same size as the pipe in which the separator is placed. Besides seeing to it that all the good things that can be desired of a separator are accomplished, we introduce no bad features to offset.

A Cochrane Separator earns steady dividends by reducing fuel bills, by keeping oil out of heating systems, boilers, etc., and there is no corresponding expenditure beyond interest on investment to be written off against it. A separator which creates back pressure, on the other hand, charges daily wages.

This and many other points about separators should be taken into consideration when you are purchasing. Send us particulars about your conditions and requirements and order one on trial.

HARRISON SAFETY BOILER WORKS,
17TH. & CLEARFIELD STS., PHILADELPHIA, PA.

TALK 7

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d'Este Co., Julian, Boston, Mass.
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Williams Valve Co., D. T., Cincinnati, Ohio.
Wright Mfg. Co., Detroit, Mich.

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Westinghouse Mach. Co., Pittsburg, Pa.

Tube Cutters

Lagonda Mfg. Co., Detroit, Mich.

Tubing

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Tubing, Metallic

Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa;

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De Laval Steam Turbine Co., Trenton, N. J.
General Elec. Co., Schenectady, N. Y.
Kerr Turbine Co., Wellsville, N. Y.
Westinghouse Machine Co., Pittsburg, Pa.
Wing Mfg. Co., L. J., New York.

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Chapman Valve Mfg. Co., Indian Orchard, Mass.
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Ohio Brass Co., Mansfield, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valve Balls

Diamond Rubber Co., Akron, Ohio.

Valve Discs

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Diamond Rubber Co., Akron, Ohio.
Mechanical Rubber Co., Cleveland, O.

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Pittsburgh Valve & Fittings Co., Barberton, Ohio.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburg, Pa.
Walch & Wyeth, Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, Ohio.

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New Bedford Boiler & Mach. Co., New Bedford, Mass.
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Nelson Valve Co., Philadelphia, Pa.

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Pittsburgh Valve, Fdry. & Construction Co., Pittsburg, Pa.
Walch & Wyeth, Chicago, Ill.

Valves, Safety Gate

Walch & Wyeth, Chicago, Ill.

Valves, Steam

Nelson Valve Co., Philadelphia, Pa.

Valves, Stop Check

Schutte & Koerting Co., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Superheated Steam

Nelson Valve Co., Philadelphia, Pa.

Valves, Swing Gate

Walch & Wyeth, Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, Ohio.

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Valves, Water

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Valves, Water Relief

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Williams & Co., J. H., Brooklyn, N. Y.

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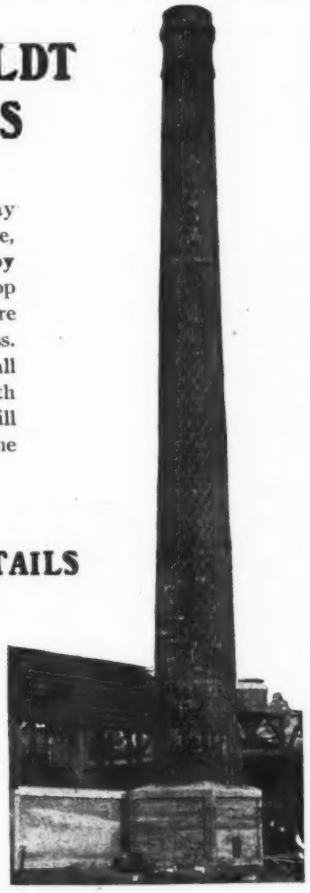

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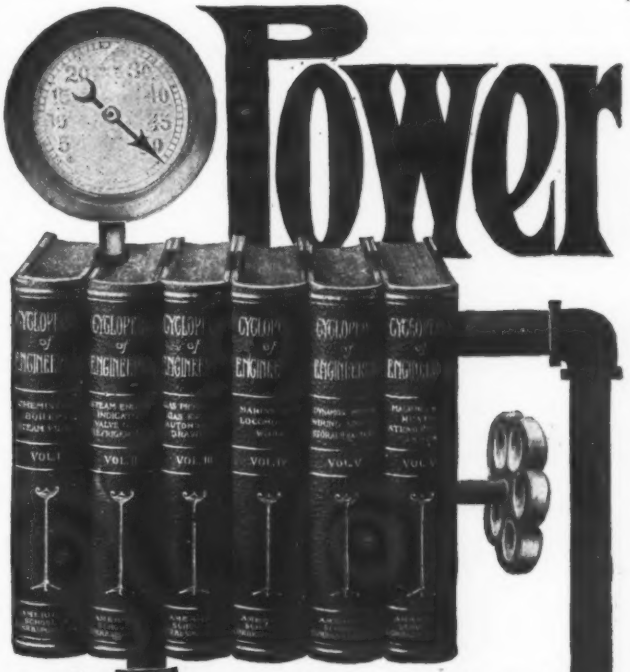

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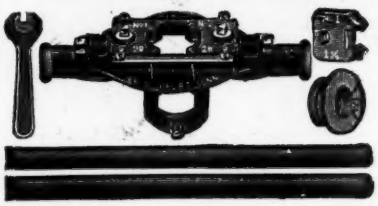

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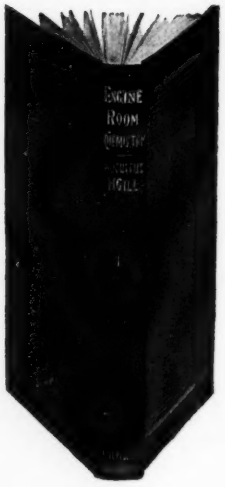

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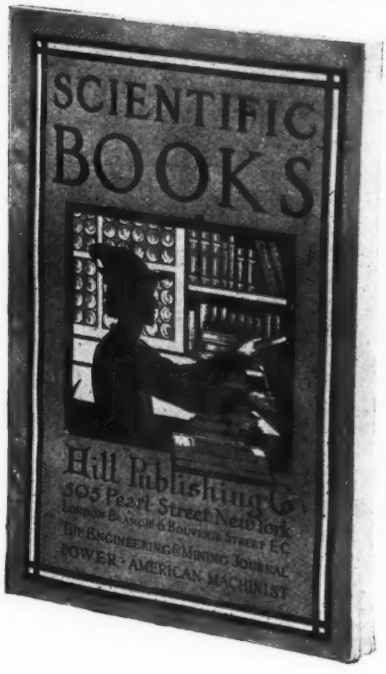

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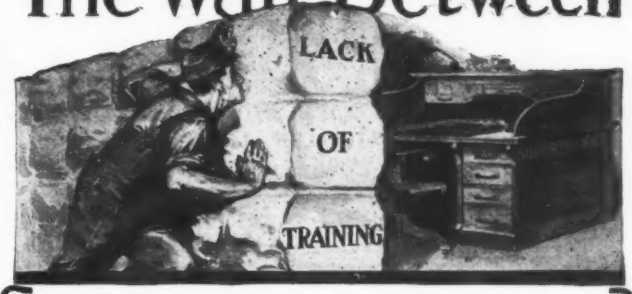

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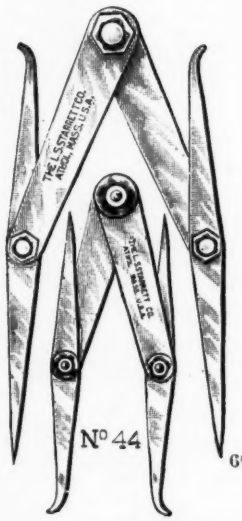

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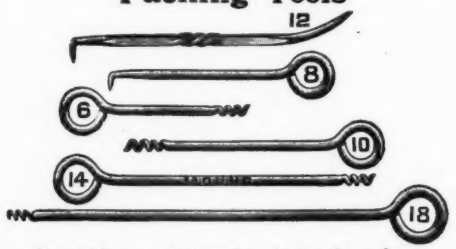

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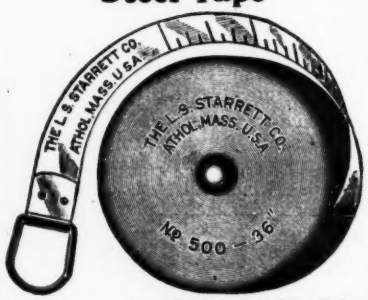

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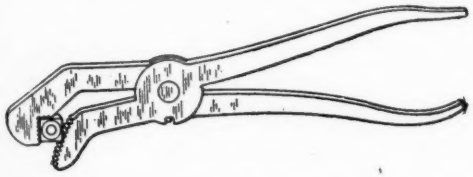

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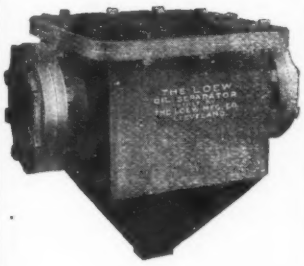

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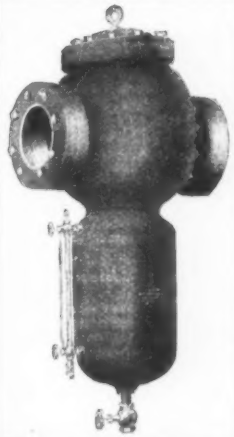

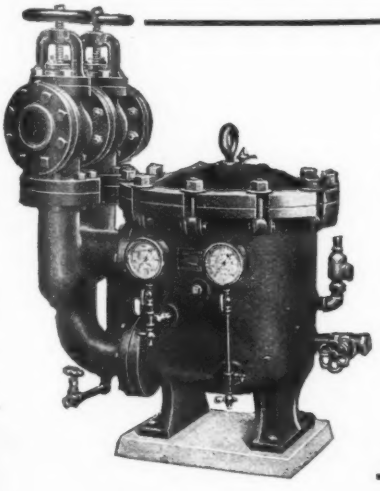

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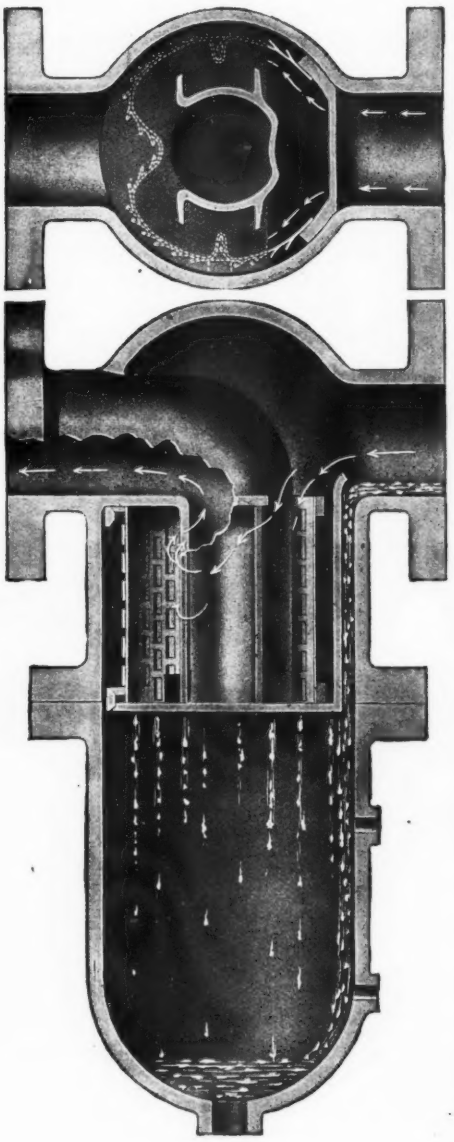


Extensive experiments by the leading experts of the country prove that there is always a stream of water flowing along the bottom of steam pipes in proportion to the square feet of radiation.

Note how this condensation is removed in the STRONG SEPARATOR without entering the steam current.

The entrained water is taken care of in this way: Steam, upon entering the separator, is changed from its cylindrical to a thin rectangular shape, and in its passage is whipped against a perforated sheet of heavy brass. This forces the condensation into the drip chamber, thence to the receiver (where it is automatically taken care of by our steam trap).

Our separators are all made extra heavy, and constructed along scientific lines.

Efficiency guaranteed.

Send for our CATALOG A-4, describing our complete line of special ties.

The STRONG, CARLISLE & HAMMOND CO.

342 Frankfort Ave., CLEVELAND, OHIO

54 No. 6th St., PHILADELPHIA

88 Broad St., BOSTON

261 Centre St., NEW YORK

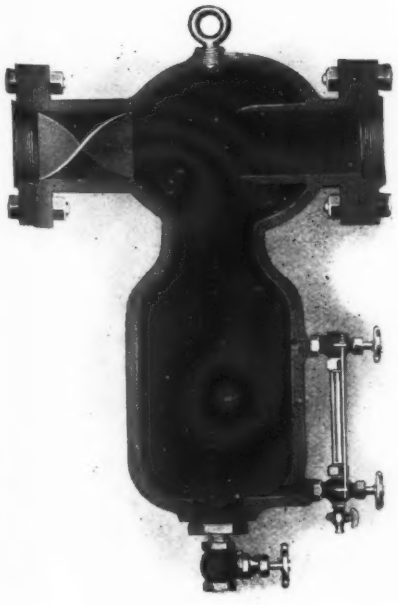
Centrifugal Force

which
results from the
Whirling Motion
given to the
steam as it
passes through
the Helix
in the

"Swartwout"

Cast Iron Exhaust Heads
Steam and Oil Separators

Absolutely Separates the Water and Oil from the Steam.



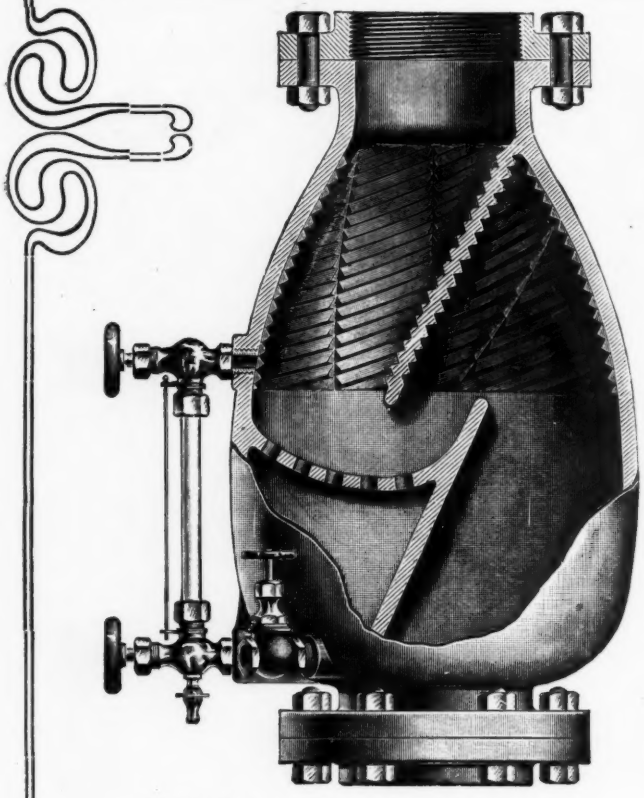
When the auto rounds the curve the tendency of everything to fly outward is restrained, but when a mass of steam revolves rapidly the action of centrifugal force upon the drops of oil and water is irresistible. In the "Swartwout" apparatus the flow is direct; there are no baffle plates; there is not an ounce loss of pressure.

There is nothing simpler.
Read about it in our new catalog No. 116-P.
To be had for the asking.

The Ohio Blower Company
Cleveland, Ohio

Also manufacturers of "Swartwout" Gravity Closing Ventilators.

LIVE AGENTS WANTED EVERYWHERE. 1-27



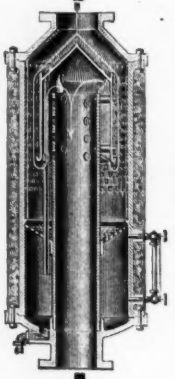
Shipped on 30 to 60 days' trial.
Send for catalog.

THE AUSTIN
Figure "A" Vertical
IRON
STEAM SEPARATOR

STEAM coming direct from the boiler to engine cylinder contains more or less water. In emergencies "slugs" of water are apt to "come over" from the boilers.

Austin Separators will separate the water from live steam, delivering to the cylinders absolutely DRY STEAM, thereby increasing the efficiency of the engine at decreased cost.

AUSTIN SEPARATOR CO.
DETROIT, MICH. 57 Woodbridge St.



SOME SEPARATORS

separate the moisture from the steam only to have the steam current pick up a good part of it again. What sense is there in that?

SWEET'S SEPARATORS

remove 99.8% of the moisture from the steam, carrying it *out of reach* of the current. It also removes 99% of the oil and has ample storage space to provide for a sudden rush of oil and water. Catalog?

DIRECT SEPARATOR COMPANY
712 Geddes Street SYRACUSE, N.Y.

American Asbesto-Metallic Packing.

Perfect for high pressure. Semi-metallic, packs like fibrous packing, wears like metallic and gives more satisfaction than either. Ask us just how it is made, or, better yet, get a sample and see for yourself.

American Steam Packing Company,
51 High Street, Boston, Mass., U. S. A.

There's Either Gold Or Grease In Steam.

If your steam contains grease a Peerless Grease Extractor will remove it and show you the way to the gold. Write.

HUSSEY, McCANN & CO.,
87 Warren St., New York.

WE DON'T ASK YOU TO RISK ONE CENT

You may have a Baum Separator entirely free of charge for 30 days. That will give ample time to test its value to you.

Write for catalog.

THE HERSHEY MACHINE & FOUNDRY CO.,
MANHEIM, PENNSYLVANIA.

W.G.Ruggles Co., 54 High St., Boston, Mass.
R. D Bliss, 40 Dearborn St., Chicago, Ill.

Have You Ever Had An Experience Like This?

If so, how did you act? Did you let the dealer talk you into taking the "just-as-good" or did you show him the Palmetto Red Tin Tag and insist on having the packing that you knew would last and remain soft.

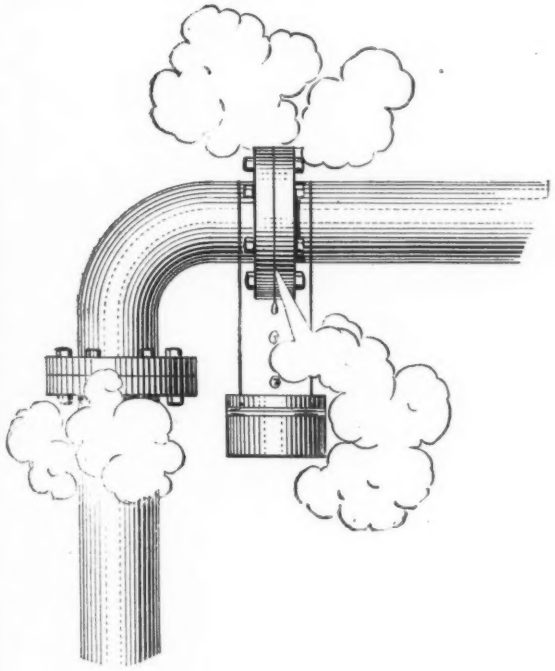
The PALMETTO red tin tag stands for quality. Insist on having the packing that bears it.

Twist (on 1 lb. spools) for small stems.

Braided, round and square, (in 5-lb. boxes) for large stems.

Send for FREE working samples.

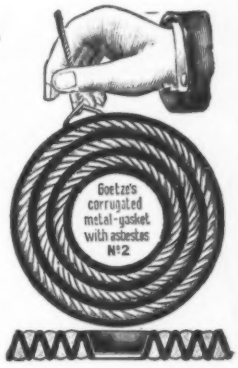
GREENE, TWEED & CO.,
Sole Manufacturers
109 DUANE ST., :: :: :: NEW YORK.



YOU KNOW that you can't afford to have your plant shut down because a gasket blows out. You must know, therefore, that you can't afford to use any but the very best gaskets obtainable.

WE KNOW that Goetze's Elastic Copper Gaskets supply a **positive** remedy for leaking joints, no matter how high the pressure or temperature.

Send for a free sample for a practical test.



The American Goetze-Gasket and Packing Co.,
525 East 149th St., New York, N. Y.

PEERLESS SPIRAL PISTON AND VALVE ROD PACKING

IS THE MOST SATISFACTORY PACKING IN THE WORLD.
IT WILL RUN FROM 12 TO 16 MONTHS WITHOUT REPACKING.
WILL HOLD 400 POUNDS OF STEAM.
IT WILL PACK TIGHTLY ANY ROD HOWEVER BADLY SCORED AND CORRODED.
WILL NOT GET HARD UNDER ANY DEGREE OF HEAT.

SOLE MANUFACTURERS OF THE CELEBRATED
RAINBOW PACKING

PATENTED MANUFACTURED EXCLUSIVELY BY

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N. B. O.

HOME RUBBER CO. TRENTON, N. J. STEAM NEVER BURN BLOW OUT. PACKING. CHICAGO TRADE MARK NEW YORK

The Original Black Sheet Packing

Insist On The Genuine

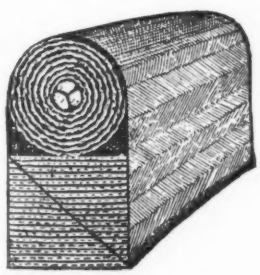
O. I. M.
on its merit

Low Pressure
Use where pressure does not exceed 100 lbs.

N.B.O., famous black sheet packing, derives its name from the fact that it will **never burn** (or) **blow out.**

We might also add that it will not squeeze or rot out either. 'Tis made of none but the very best materials, and GUARANTEES SATISFACTION under strenuous service.

O. I. M.
on its merit



High Pressure
Use where pressure is above 100 lbs.

O.I.M. Packing

This is the IDEAL packing to use on scored or uneven rods. The two diagonally cut wedges slip on each other and conform with extreme readiness to any uneven surfaces.

The LOW PRESSURE packing has an absorbent cushion, while for high pressures we make it with a round, highly elastic, hard friction tuck.

Your dealer should supply you. If he cannot do so, write to us direct. Test is the master proof.

Home Rubber Company

Woolverton Avenue, Trenton, N. J.

NEW YORK
80 and 82 Reade Street

CHICAGO
27 N Jefferson St. W. J. Williams & Co.

LONDON--Balfour House
Finsbury Pavement

Cobbs High Pressure Spiral Piston and Valve Stem Packing

The Rubber core is made of an oil and heat resisting compound, wrapped with a well frictioned Duck, with an outer cover of fine asbestos, lubricated by our secret process.

It is made round or square, in coil or spiral form especially adapted to withstand heat and high pressure. We guarantee "Cobbs" Packing will pack any rod perfectly tight, as it will not get hard under any degree of heat.

"Cobbs" Packing also furnished in rings at short notice, made of round or square packing.

Indestructible White Sheet Packing

Is without doubt the toughest and most durable High Pressure Sheet Packing on the market. It will stand the highest pressure and extreme heat, making a tight joint when used for Steam, Air, Hot or Cold Water.

It does not dry out or become hard and brittle, but retains its tough elastic qualities, either in or out of service. Ammonia, Liquor, Alkali, Oils or Acids have little or no effect on it, and joints can be broken numerous times without renewing the packing.

Indestructible White Sheet Packing is also made with wire insertion.

We manufacture a complete line of high class rubber goods, comprising Belting, Air, Fire, Garden, Steam, Suction, Pneumatic Tool and Water Hose Packings, Gaskets, Mats, Matting, Stopples, Special Mould Goods, Interlocking Rubber Tiling, Tubing, etc.

SOLE MANUFACTURERS

New York Belting & Packing Company, Ltd.

91 and 93 Chambers Street, New York, N. Y.

CHICAGO, 150 Lake St.
ST LOUIS, 218 220 Chestnut St.
PHILADELPHIA, 118-120 N. 8th St.
SAN FRANCISCO, East 11th St and 3d Ave., OAKLAND.
BOSTON, 232 Summer St
INDIANAPOLIS, 229 S Meridian St.
BALTIMORE, 114 W. Baltimore St.
BUFFALO, 600 Prudential Bldg.
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SPOKANE, WASH., 163 S. Lincoln St.
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FIVE REASONS FOR USING

TRADE MARK

MARCO

REG. IN U.S. PAT. OFF.

PACKINGS

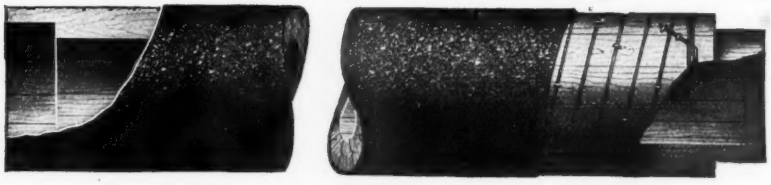
They are Made on RIGHT PRINCIPLES
of BEST MATERIAL
by PRACTICAL MEN
with SKILFUL EXPERIENCE
for ANY SERVICE

Have you used them? Do you know them?
It can do no harm to send a postal. Write *to-day*

THE CLEVELAND RUBBER WORKS

of The Mechanical Rubber Co.

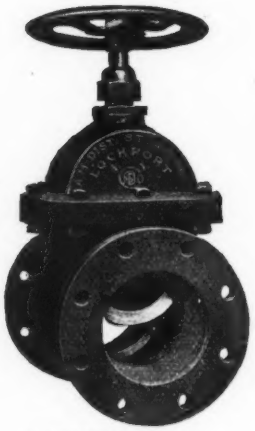
No. 68 Lisbon Road, CLEVELAND, OHIO.



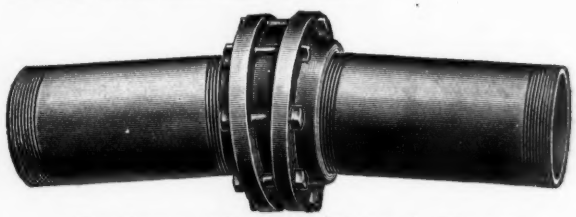
"OUR STANDARD" STEAM PIPE CASING

A FEW OF OUR STEAM SPECIALTIES

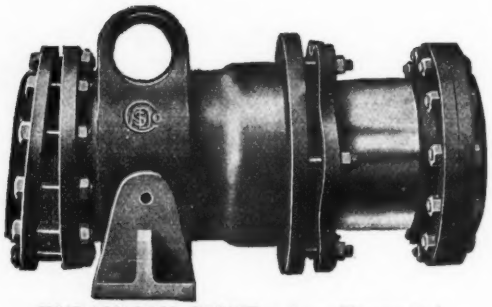
STEAM AND OIL SEPARATOR



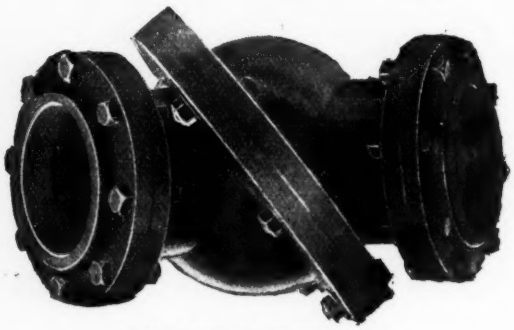
PACKINGLESS GATE VALVE



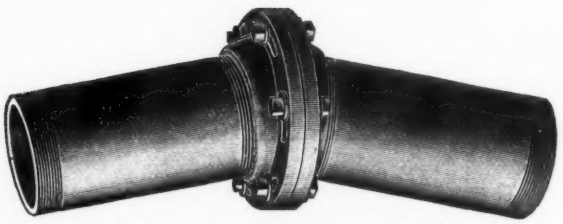
"Cut Shows Adjustable Wedge in Place."
ADJUSTABLE ANNULAR WEDGE



EXPANSION JOINT (Any Traverse)
DOUBLE OR SINGLE



90° ANGLE JOINT



"Method of Making Angle with Slotted Angle Flange."
SLOTTED ANGLE FLANGES

WRITE FOR INTERESTING PRICES.

AMERICAN DISTRICT STEAM CO.

LOCKPORT, N. Y. N. TONAWANDA, N. Y. CHICAGO.

Look Into Eureka Packing

You will find its quality, efficiency and lasting power worth knowing about. On all kinds of difficult jobs it greatly outlasts the best of other makes.

It's Way Out Of The Ordinary

Eureka Packing is made of the finest materials by expert workmen; it is invaluable for uneven, worn or fluted rods; it requires less repacking than any other and *its cost is about one-third less. We also make Cut Ring, High Pressure, Water Proof, Hydraulic, in rings and coils, Spiral and Red Sheet Packings.* Ask us for details and prices.

Eureka Packing Company,

SALES DEPARTMENT,

Jas. L. Robertson, Pres't. **46 Warren St., New York.**

FOR YOUR ENGINE

Buy A Robertson-Thompson Indicator

and Victor Reducing Wheel which makes an outfit that furnishes perfectly accurate records of exactly what the engine is doing at all times. They are sold at a moderate price on easy terms. *Ask for particulars.*

JAS. L. ROBERTSON & SONS,

46 Warren Street, **NEW YORK.**

ENGINEERS WHO HAVE USED

INDIAN RED SHEET PACKING

Will tell you it has the
STAYING AND RESISTING QUALITIES

It is efficient in every respect
which, in the end, means economy.

A 14 x 28 hanger, like cut herewith, but in colors,
free to any engineer upon request.

The DIAMOND RUBBER CO., AKRON, OHIO.

Complete Diamond Stocks Carried By

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The Diamond Rubber Co.,
1523 Michigan Ave., Chicago, Ill.
The Diamond Rubber Co ,
Mission and 2nd Sts., San Francisco, Cal.
Buffalo Mill Supply Co.,
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Southern Hardware & Supply Co.,
Mobile, Ala.
Consumers Rubber Co.,
Cleveland, Ohio.
The Diamond Rubber Co. of N. Y.,
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3963 Olive St., St Louis, Mo.
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Pittsburgh Rubber & Leather Co.,
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Belmont Packings

"The Big Three."

BELMONT EXPANSION NO. 1.
BELMONT HIGH PRESSURE NO. 50.
BELMONT HYDRAULIC NO. 8.

Belmont Expansion No. 1.—For ammonia and for steam up to 125 lbs. pressure. The two wedges are independently movable within the casing. By pulling one forward an inch or two, and pushing the other back an equal distance, the break, when the ring is closed, is divided into three parts occurring at different points around the circumference. This feature enables one ring to hold steam or ammonia as well as three rings of any other packing, and makes it invaluable for shallow stuffing boxes. Write for booklet A.

Belmont High Pressure No. 50.—The *only safe packing* for high pressure, high speed and superheated steam. Made with asbestos wedges, special rubber compound back and casing, and lubricated by high test compound in connection with best Ceylon graphite. Nothing to char or become brittle. Highest steam pressure and superheat easily resisted. Outlasts others, keeps rods in perfect trim. The *only modern high pressure packing* on the market. Write for booklet B or booklet H (special booklet on locomotive packings).

Belmont Hydraulic No. 8.—A *Modern Hydraulic Packing* for pump rods and plungers—not for steam. *See the stitching!* This packing is stitched through and through crosswise; cannot *twist*, *swell* or *pinch*. Braided flax core, casing of finest cotton duck and rubber. Especially valuable for alkaline or sulphuric acid mine water. Write for booklet C.

A full line of other packings for every known purpose. Large general catalogue free on request. Sample ring of any packing free. Fill in coupon stating kind wanted.

Salesmen Wanted.—To call at power plants, pumping stations and engine rooms and sell BELMONT PACKINGS and Specialities. Particularly attractive proposition for manufacturers, agents and engineers in territory not already covered.

Clement Restein Co., Phila., Pa.
Gentlemen:—Send me a sample ring of .....
Name .....
Address .....
Firm name .....
No. engines..... No. pumps.... No. boilers....
High or low pressure .....
Packing now in use .....

CLEMENT RESTEIN CO.

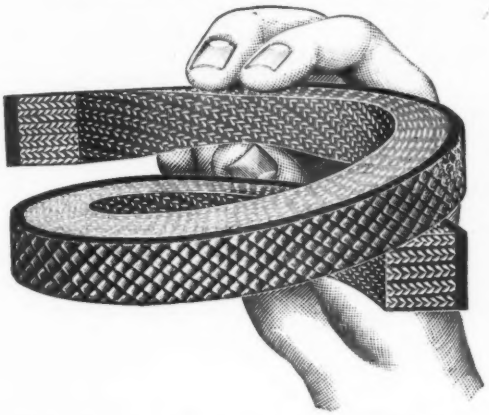
133 NORTH SECOND ST., PHILADELPHIA, PA.

Note the Compressibility of

RUBBERBESTOS

(Trade Mark Registered)

SPIRAL PACKING



It is due to its elastic band of Rubberbestos which *encircles* the rod giving *expansion directly on it*—and to its diagonal construction which allows *compensation* for wear.

A. W. CHESTERTON CO.,
64 INDIA ST., BOSTON, MASS.
or ADVANCE PACKING & SUPPLY CO.,
123 Franklin St., Chicago, Ill.

WEARWELL LEATHER PACKINGS

ALWAYS THE SAME.

Made in all sizes for Hydraulic and Compressed Air Machines.

Write for Catalog and Samples.

DETROIT LEATHER SPECIALTY CO., INC.,
175 Beecher Avenue, Detroit, Mich.

BRISTOL HYDRAULIC PACKING

Especially recommended for high pressures.

Saves time, labor and PACKING. Outlasts all others and will not blow out.

Try it on some of those "impossible places." Write for prices and full particulars.

NATIONAL INDIA RUBBER CO.,

BRISTOL, = R. I.

BRANCHES:

42 Broadway, New York
84 Lake St., Chicago
140 Essex St., Boston
37 Hopkins Pl., Baltimore
379 Washington St., Buffalo

Zena-Asbestos Gaskets

will not blow out—Are **Tough, Pliable** and can be used over several times.

Brandt's Pump Valves

for Condenser, Feed and other services will last longer and save money and trouble. Will stand oil and hot water.

State requirements.

Randolph Brandt,
72 Cortlandt Street, New York, U. S. A.

"SAFETY" PLASTIC METALLIC PACKING

For Steam, Water, Air, Gas, Hydraulic Machines, Valves, Etc.

Guaranteed to stand Steam Temperature up to 550° F. and Hydraulic Pressure to 5000 lbs. per square inch.

Highest Award World's Fair, St. Louis.

Send for FREE SAMPLE and particulars.

MANUFACTURED BY
STEEL MILL PACKING CO., Detroit, Mich., U.S.A.

THE BEST MATERIAL

used as the best material should be used and in generous quantities—the result is Johnson's Peerless Packing. Write for particulars.

The HENRY JOHNSON COMPANY,
175-187 Gates Avenue, Jersey City, N. J.

Guaranteed Unconditionally

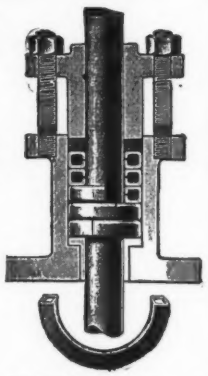
for ammonia, water, air and superheated steam.

Huhn Metallic Packing

is composed of hollow rings of soft alloy filled with lubricating material which escapes in just the right proportion and in just the right place.

Write for booklet and sample.

American Huhn Metallic Packing Co.
1876 Broadway, New York.

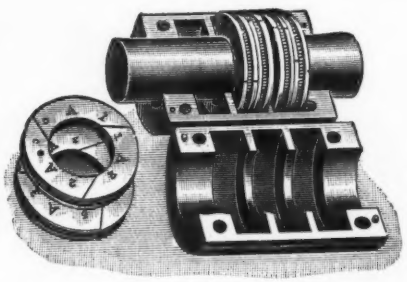


Operating under U. S. Patents.

Your Packing Troubles End

when you put Bridgeport Improved Ring Packing on the rods of your vertical or horizontal engines.

It is simple, lasting, easy to apply and it is so flexible it floats with the rod. No square shoulders to limit wear of rings. Give it a trial—we'll take no money unless you're satisfied. Booklet?



The Bridgeport Metallic Packing Co., 628 Railroad Ave., Bridgeport, Conn.

THE PACKING WITH REAL HOLDING QUALITY

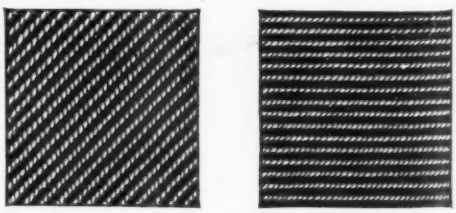
Pat. March 15 1898

DODS Diagonal Piston Rod Packing

is all one piece, made from high-grade Rubber and Duck in layers placed at a diagonal from every side. This construction gives "Dods" a cross expansion of 100%. It will hold steam, air or liquids when all other packings fail.

Send for test samples and description. Address Dept. P.

CROSS-SECTIONS OF "DODS" PACKING. ORDINARY PACKING.



☞ **These Cross-Section Views Show Why!**

CHICAGO **BOWERS RUBBER WORKS** **SAN FRANCISCO**

DAVIS PRESSURE REGULATORS SAVE STEAM

PRESSURE REGULATOR

Do It Automatically

If you are using live steam for heating, drying, cooking or some other purpose at a pressure lower than that carried on the boiler, let the Davis Pressure Regulator make the reduction for you automatically.

This valve can be adjusted to deliver steam at just the pressure needed and it will maintain that pressure without fluctuations no matter how much the initial boiler pressure may vary.

Reducing steam by throttling through a cracked globe or gate valve is about as satisfactory as using saw dust for fuel. You may be able to get along after a fashion, but why not do it right—automatically.

If you are running your engine non-condensing a Davis Automatic Back Pressure Valve will enable you to make use of the exhaust steam instead of letting it go to waste.

Contrast this valve with its semi balanced disc, small weight and noiseless operation without any possibility of injury to the seats, with the old style single seated valve which pounds like a trip hammer and keeps you poor buying seats for it. Is there any comparison—would you choose the single seat ?

Send for a complete catalog of Davis Valve Specialties. It is of interest to both owner and operator.

G. M. Davis Regulator Company,
142 Milwaukee Ave., CHICAGO.

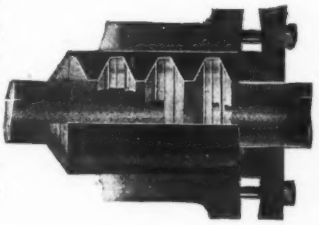
BRANCHES—NEW YORK—123 Liberty St. BOSTON—104 High St. ST. LOUIS, 735 S. 4th St.
SAN FRANCISCO—216 California St PHILADELPHIA—56 N. 2nd St.
PITTSBURGH—1206 Park Building.

BACK PRESSURE VALVE

GOOD NEWS

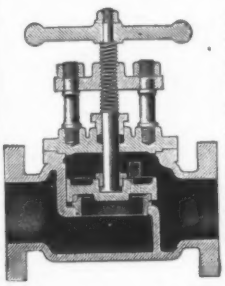
There is no further need for *Soft Packing Bills*. Sterling Metallic Packing packs better and is *much more economical*. It keeps the rods smooth, steadies them, and lasts as long as the engine.

Its construction is unique. Write for Catalog.



Monarch Steam Blower Co.,
TROY, N. Y,

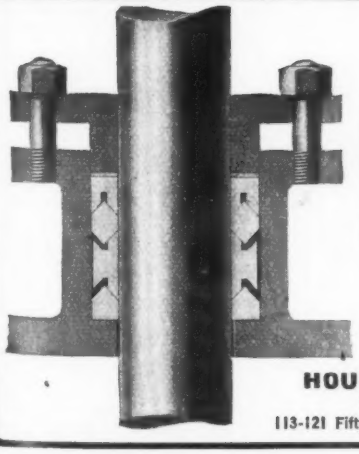
"BELLVILLE VALVES"



have the seat on the outside of an inverted cone where the direct current of steam does not come in contact with it, preventing all chance of wire drawing. Other features in catalog.

Heavy, Compact, Durable,
no marring by pipe tongs.

Eastwood Wire Manufacturing Co.,
BELLEVILLE, NEW JERSEY.



The Simplest Packing To Apply

LAW

IMPROVED
Metallic Packing

is also the most lasting, the most secure and in the end most economic.

HOUCHIN-AIKEN CO.,
Sole Manufacturers,
113-121 Fifty-third Street, Brooklyn, N. Y.

Erwood Swing Gate Valves
Manganesite Paste for Joints

WALCH & WYETH, 87 Lake St., Chicago.

A "BANG-UP" GOOD PACKING

TORPEDO

Asbestos Packing; used by Uncle Sam's torpedo boats. The hardest-to-pack joints yield to "Torpedo." Circular?

OSGOOD SAYEN 421 Arcade Bldg, **Philadelphia, Pa.**

SATISFACTION!

That is what you get with every
Lunkenheimer
Regrinding Valve.

The smallest detail is given careful consideration, making the valve as a whole the most durable and practical obtainable. Remember, that not only can the seat bearings be reground, but the disc can be renewed.
You can have a copy of our catalogue for merely the asking.

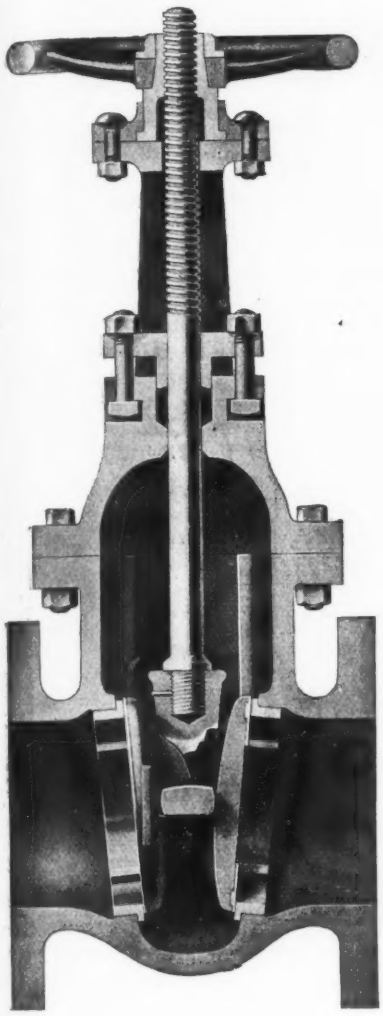
The Lunkenheimer Company

Largest Manufacturers of High Grade Engineering Specialties in the World

General Offices and Works, Cincinnati, Ohio, U.S.A.

Branches: New York, 66-68 Fulton St.; London, S. E., 35 Great Dover St.; Chicago, Lake and Dearborn Sts.

187



Nelson Valves

Advantages through Compactness of Design

Numerous tests have decisively proven that the walls of Nelson Valve bodies are much stronger than other valve bodies with longer face to face dimensions; and the same is true when the Nelson type is tested in comparison with valve bodies of the *same* length, which are greatly weakened by the large recesses necessary to accommodate complicated spreading devices.

The Nelson body is stronger because the working parts are few and simple—two discs and one wedge—and require only small space, allowing the body to be made short and compact and exposing only a small area of metal to the destructive elements. This compact body is made extraordinarily sturdy by concentration of strength values where most required, assisted by the flexibility of a simple, effective mechanism that compensates for any distortion caused by extreme pressure or by violent shocks or strains of any sort.

The extraordinary strength and the superiority of the working parts enable us to guarantee Nelson Valves—absolutely and expressly

The Nelson Valve Company
Philadelphia

New York, Hudson Terminal Bldg.
Chicago, . . 40 Dearborn Street
Pittsburgh, . 525 Third Avenue
Minneapolis, . . 622 Andrus Bldg.
San Francisco, . Atlas Building
Butte, Mont., . 56 E. Broadway

VALVES

Makes no difference what kind of a Valve you want, how you want it made or where you want it shipped, we can supply it on shortest possible notice.

We manufacture valves and pipage equipment of every description, for all kinds of plants, Steam Separators, Tuyere Cocks, Brass Unions, Etc. Also make Pipe Bends, and do all kinds of Pipe Fitting, either assembled or ERECTED.

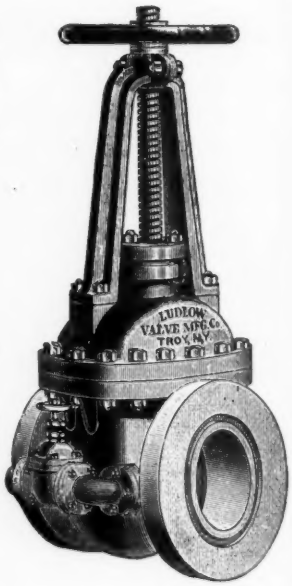
SEND FOR CATALOG

PITTSBURGH VALVE FOUNDRY & CONSTRUCTION CO.

Pittsburgh Cleveland New York Boston Birmingham, Ala.

IT'S ECONOMY

to purchase Ludlow Valves. There's *longer life* and *better service* in the genuine "Ludlow."



LUDLOW VALVES

are carefully made and thoroughly tested. Ask any Ludlow Valve user what he thinks of them.

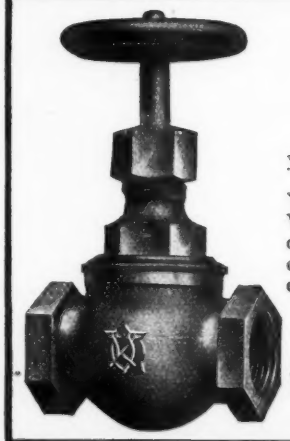
Catalog ?

THE LUDLOW VALVE MFG. CO.
Adams Street,
Troy, New York, U. S. A.

All Valve Records Are Broken

by Homestead Four-Way High Duty Operating Valves for air, hydraulic or steam service. They give most highly satisfactory results and outwear all others. There's great economy in their durability. Booklet?

HOMESTEAD VALVE MFG. CO.,
PITTSBURG, PA., U. S. A.



LEAKS LEAVE

your plant when Kennedy Valves come in.

You see a Kennedy Renewable Disc Valve can't leak because the valve discs are made of a compressible composition which conforms to uneven surfaces.

Write for catalog.

The Kennedy Valve Mfg. Company,
Elmira, N. Y.

ECLIPSE

Vacuum - Pressure Regulating Valve.

For atmospheric vacuum or very low pressure Heating Systems. Highly sensitive, responds promptly to slightest variation in pressure.

A two-seated valve, so constructed that the seats adjust themselves to any change of temperature, consequently they are always tight under varying pressure. This is a device that no other valve of this kind on the market has.

Write for detailed particulars concerning this valve.

"ECLIPSE" Steam Specialties

"E Reducing Valve
C Low Pressure Regulating Valve
L Back Pressure Valve
I Vacuum Pressure Regulating Valve
P Automatic Pump Governor
S Pump Regulator
E" *Distinctive points of merit in principle of construction, supported by the best of material and superior workmanship—count for the satisfactory performance of every device in use.*

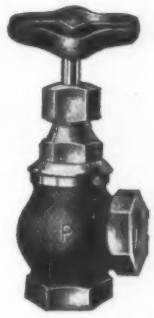
CATALOG of detailed information covering our complete line on request.

JOHN DAVIS COMPANY,

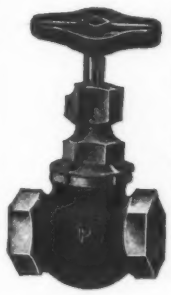
HALSTEAD, 22ND and UNION STREETS, CHICAGO.

W. G. Ruggles Co., Boston. Western Valve Co., St. Louis
Central Supply Co., Indianapolis, Ind.
Robert B Orr Engineering Co , Kansas City, Mo.
J. A. Roe & Co., Detroit, Mich. A. M. Lockett Co., New Orleans, La.

Insist on Pittsburgh Valves



and Fittings. It is impossible for human skill to produce better or more reliable equipment than that stamped with the sign of quality—"P."



Pittsburgh Brass Globe Valves

Made in a superior manner of the highest grade steam metal and sold under our binding guarantee.

If better work and longer life mean anything to you, insist on "P" products.

PITTSBURGH VALVE & FITTINGS COMPANY

General Offices and Works: BARBERTON, O.

WE MANUFACTURE ALL KINDS OF VALVES AND FITTINGS

WHALE BRAND VALVES

have Seats and Discs of Nickel Bronze. They are sold under a guarantee to remain tight under all conditions.

Remember—the **Whale Brand** is found only on New Bedford Valves. Better valves cannot be purchased at any price. Write for complete catalog.

NEW BEDFORD BOILER & MACHINE COMPANY,

ESTABLISHED 1872.

NEW BEDFORD, MASSACHUSETTS.

YORK MANUFACTURING CO.,

YORK, PA.

We manufacture all the machinery and parts needed to equip a complete Ice or Refrigerating Plant—Machines, Condensers, Tanks, Cans, Coolers, Piping, Boilers and Ammonia Fittings of all kinds.

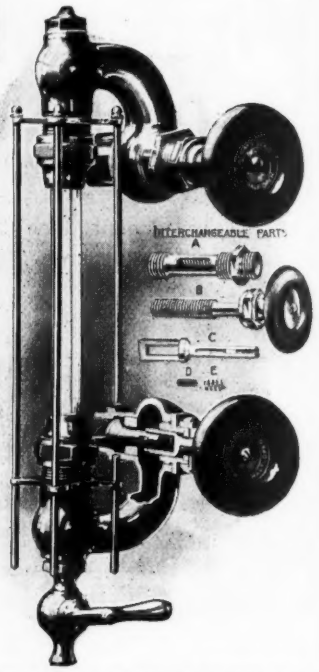
We employ over 1250 men in the manufacture of Ice and Refrigerating machinery exclusively.

CATALOG UPON REQUEST.

Our fittings carried in stock at the following places:

York Manufacturing Co.,	1660 Monadnock Block,	Chicago, Ill.
York Manufacturing Co.,	72-76 Trinity Place,	New York, N. Y.
York Manufacturing Co.,	20 South Main St.,	St. Louis, Mo.
York Manufacturing Co.,	318 Liberty Ave.,	Pittsburg, Pa.
York Manufacturing Co.,	13 S. Forsyth St.,	Atlanta, Ga.
Wegner Machine Co.,	Perry and Mississippi Sts.,	Buffalo, N. Y.
United Iron Works,	231 E. Second St.,	Los Angeles, Cal.
United Iron Works,	Second & Jefferson Sts.,	Oakland, Cal.
United Iron Works,	109 Main St.,	Seattle, Wash.
Braman, Dow & Co.,	239-245 Causeway St.,	Boston, Mass.

U.S. GOVERNMENT Approval



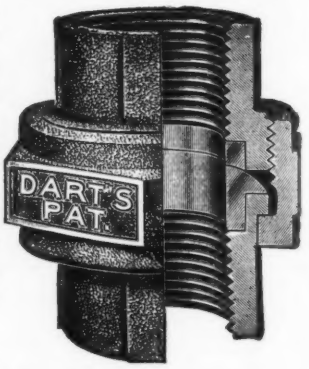
proclaims the Stulp Automatic Safety Water Gauge to be of the highest efficiency and reliability. This device also won a Medal and Diploma at the Jamestown Exposition. It automatically grinds its own valve seats and cleans its way to the boiler.

Guarantees longer life to the boiler, fewer leaky flues and safety to your men.

Write for catalog and read what users think of it.

The AUTOMATIC SAFETY WATER GAUGE CO.
Fred. J. Stulp, Prop.
MUSKEGON, MICH.

Iron Will Rust
if
Exposed to Moisture!



Both ends of a Dart Union have bronze metal seats, and is the only Union that is made of malleable iron and bronze that is immune under all conditions from corrosion.

Catalogue is ready for you.

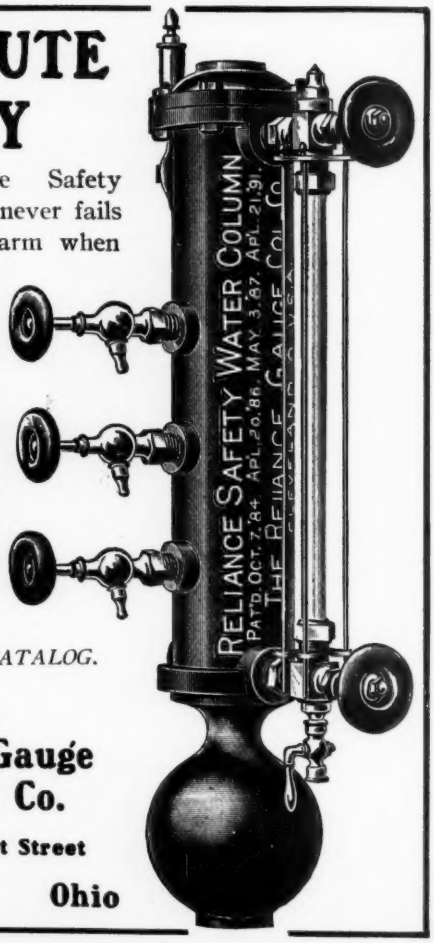
E. M. DART MFG. CO., Providence, R. I.

Over 600,000 of Kunkle's Patent Lock-up Pop Safety Valves now in actual use.

For Portable, Stationary, Locomotive and Marine Boilers. They meet every requirement. We also make Mufflers for Locomotives. Write for details and prices.

Fort Wayne Safety Valve Works,
E. B. Kunkle & Co.,
817 Barr St., Fort Wayne, Ind.

ABSOLUTE SAFETY



The Reliance Safety Water Column never fails to sound the alarm when the water drops too low or rises too high. It enforces a steady water level and consequently steady steam presssure and steady power. More in use than all other makes combined.

WRITE FOR CATALOG.

The Reliance Gauge Column Co.
75 E. Prospect Street
Cleveland, Ohio

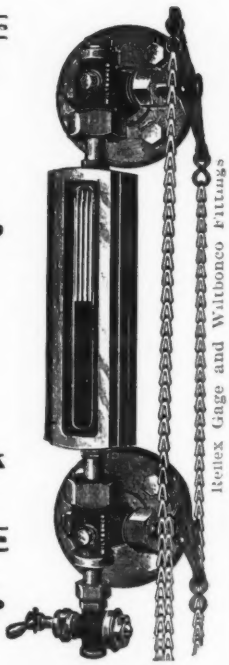
AS BLACK AS THE ACE OF SPADES

The water in a Reflex Water Gage shows **black** under all conditions.

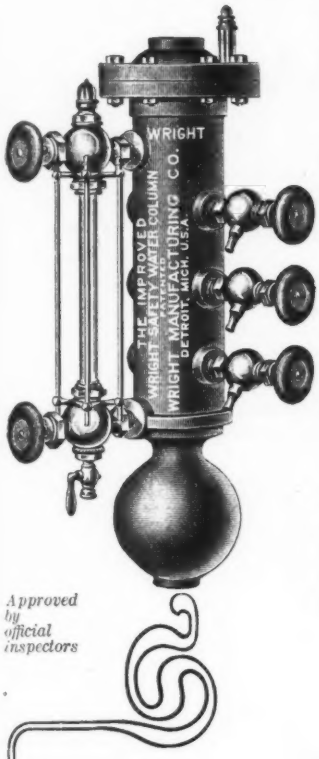
If you can't see it, See your doctor

Reflex Gages are used by the world's greatest Navies. Easy to set and clean.

The Water Shows Black
CATALOG ?



JERGUSON MFG. COMPANY,
219 Columbus Ave., Boston, Mass.

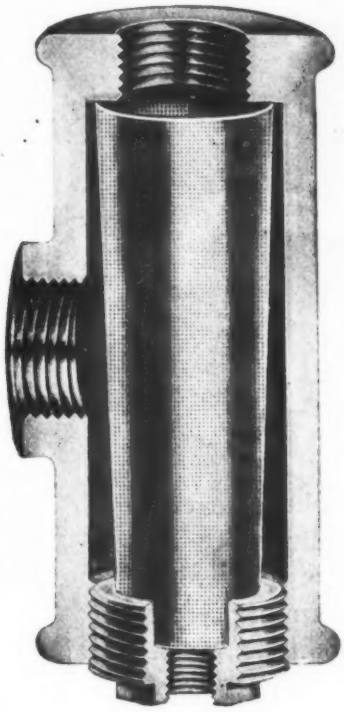


Approved by official inspectors

The
Wright Improved Safety Alarm Water Column

Shrieks a piercing blast of the whistle whenever the water level in a steam boiler approaches the danger line.

One Valve
One Float
One Whistle

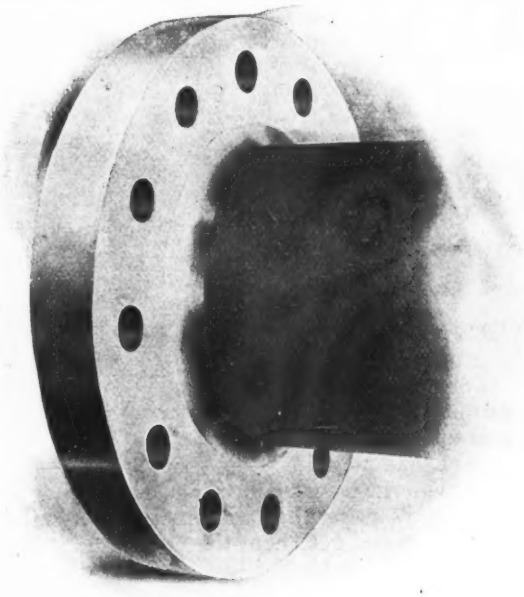


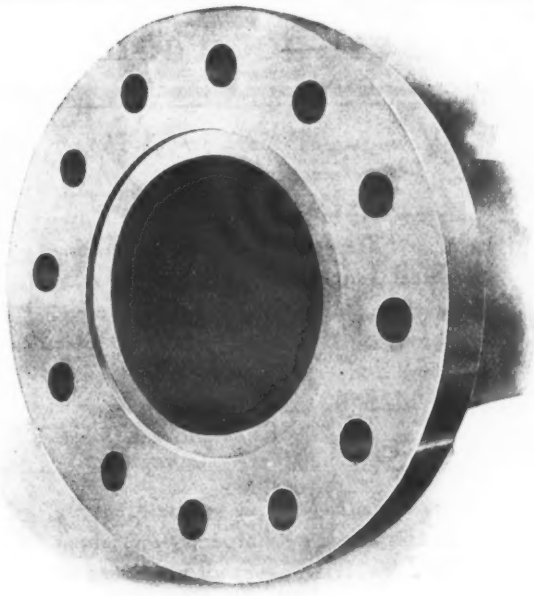
Wright Filter

A NEW, simple, dependable and *very inexpensive* little device for preventing grit, dirt, pieces of scale, etc., from entering Steam Trap Valves. Steam and water systems, meters, etc., approved by the highest authorities. Attach one to your steam trap and note the improvement.

WRIGHT MANUFACTURING CO.

DETROIT, MICH. **27 WOODBRIDGE ST.**

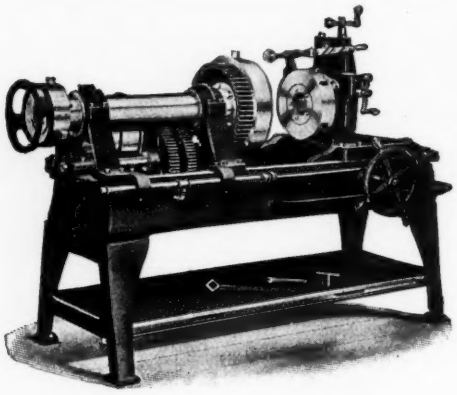




Ballwood Welded Flanges surpass all others in efficiency, durability, moderate first cost and promptness of delivery. If you want the best flanges that can be made, order Ballwood.

THE BALL & WOOD CO., Elizabethport, N. J.

Builders of Ballwood Engines. **New York Sales Office, Cortlandt Bldg., 30 Church St.**



STEP

into most any shop where several makes of pipe machines are installed, and if any are in use, it's a B. & K. The workman prefers to run the B. & K. machine because it is easy to operate and always makes good threads.

BIGNALL & KEELER MFG. CO.,
EDWARDSVILLE, ILL.

CHAPMAN VALVES

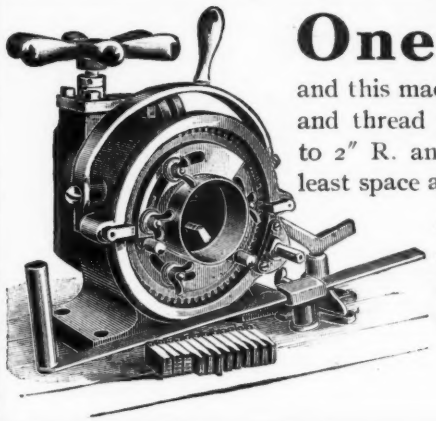
Chapman Valve Mfg. Company,
Indian Orchard, Mass.

Gages and Wages

The man down in the boiler room,
Who uses ASHTON GAGES,
Is very apt to find that soon
He's getting higher wages.

SHALL WE TELL YOU WHY?

THE ASHTON VALVE COMPANY, Boston, U. S. A.
NEW YORK St. John's House, London, Eng., CHICAGO.



One Man

and this machine can cut and thread pipe from $\frac{1}{4}''$ to $2''$ R. and L., in the least space and time.

Have the Circular?

The Curtis & Curtis Co.
85 Garden St.,
Bridgeport, Conn.

You are in good company

When joining the users of Dexter Valve Reseating Machines.

Every ship in the U. S. Navy, Railroads and Steamship Companies, Mining and Steel Industries, Chemical Works, Breweries, Public Institutions, Hotels, Department Stores, including the Diamond Mines of South Africa, and Sugar Mills in the remote parts of the South, keep their valves tight with these machines.

You can easily satisfy yourself regarding joining the list by ordering a machine on 30 days' trial, use it all you want to and then return it at our expense if you care to get along without.

Send for catalog P illustrating these machines.

The Leavitt Machine Co.,
Orange, Mass., U. S. A.

ALL IN A DAY'S WORK

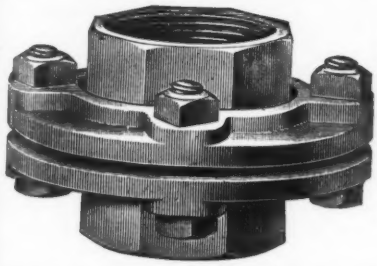
Threading an 8-inch Pipe Bend with a No. 3 "Toledo."

THE engineer and steam-fitter at times are "up against" a job of pipe-fitting under circumstances and in places as nearly like "hell" as he'll ever know. It is work that with more spectacular surroundings would get them the Carnegie Medal. Yet nothing is said about it—"it's all in the day's work."

The least that can be done for these uncrowned heroes is to see that they have tools with which this necessary work may be accomplished most easily, most quickly, in the best manner, and in any place or under any circumstance. Tools that will work right and stay right. TOLEDO PIPE THREADING DEVICES have made the world's work of threading pipe under adverse circumstances easy. Want to know more about them? Will be glad to tell you.

THE TOLEDO PIPE THREADING MACHINE CO.
TOLEDO, OHIO, U. S. A.

A LOOSE COLLAR



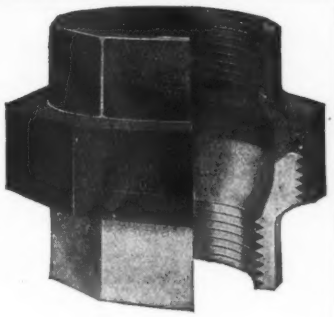
is a big feature peculiar to the Jefferson Flange. Tight connections can be made even though the pipes are out of line. Spherical joints—flat discs do not come together. See!

Write for catalog.

THE JEFFERSON UNION CO.,
31-37 Fletcher Street, Lexington, Mass.

It's Best
It's Cheapest
It's Simplest

It's the "Kewanee" Union



"Best"—because it will not leak, and is easily and quickly installed, disconnected or reconnected.

"Cheapest"—because it needs no gaskets, never rusts or corrodes, and so can be used indefinitely. It comes apart easily without hammering.

"Simplest"—because it has but 3 parts.—there are no **inserted** pieces. Brass-to-iron thread connection and ball-joint seat that is always tight, without using a gasket.

Ask us to prove all of this.

NATIONAL TUBE CO., Pittsburg, Pa.

District Sales Offices:

Atlanta	Denver	New York	Pittsburg	St. Louis	Salt Lake City
Chicago	New Orleans	Philadelphia	Portland	San Francisco	Seattle

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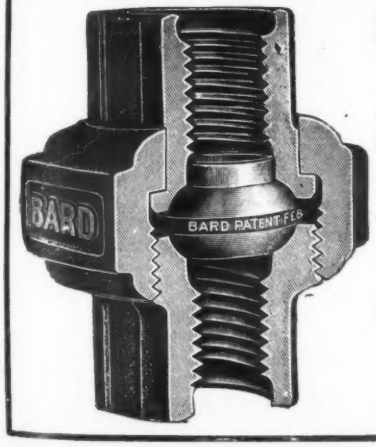


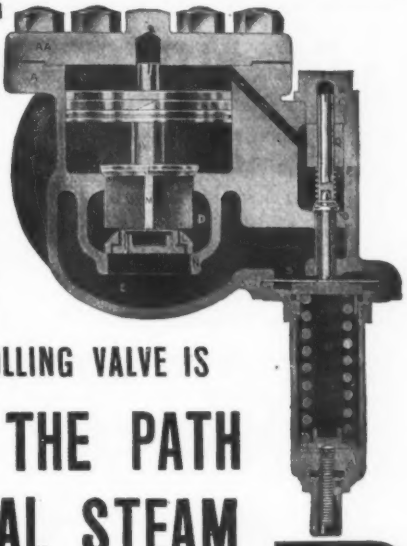
BE A "BARD" BUYER

and secure freedom from leaky joints. The "Bard" can't spread as it is *recessed* at both ends.

Write for the "Bard" Book.

The Bard Union Company,
Incorporated,
Norwich, Conn.

COLLIN STEAM PRESSURE REGULATING VALVE



THE CONTROLLING VALVE IS

OUT OF THE PATH OF INITIAL STEAM

This feature protects the controlling valve from scale and dirt and is only one of the many advantages possessed only by the Collin Valve.

Made in bronze from ¾ to 2½ inches and iron body, bronze lined, from 3 to 8 inches.

CATALOG P-B MAILED ON REQUEST

THE OHIO BRASS COMPANY,
Mansfield, Ohio, U. S. A.

New York, 32 Cortlandt St., St. Louis, 10 No. Fourth St.
Chicago, 277 Dearborn St. San Francisco, 138 Front St.

The Leakless Gauge Cock

The valve pencil is made of selected metal of lasting quality—1" long. It is the only part that ever needs renewing, and it can be worn down to the stem and then replaced for a few cents. The worn pencil is easily removed.

Let us send you proof that you want the
"P. B. H." Weight Gauge Cock.

Sent on 30 Days' Trial

Guaranteed Leakless For Years

The Paul B. Huyette Co.

2025 Betz Bldg., Philadelphia, Pa.

The More It Works The Sharper It Gets

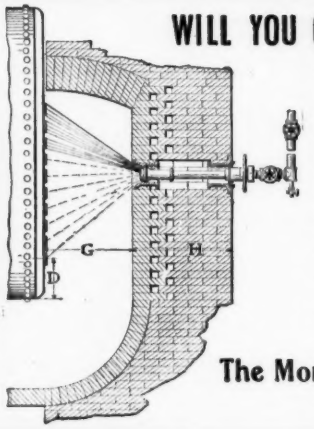
The Perfection Flue Cleaner will remove every particle of foreign matter from the tubes without doing the least injury.

We want you to try one entirely at our expense for 30 days, if not *perfectly* satisfactory don't pay for it. *"Blue Book?"*

SCULLY STEEL & IRON COMPANY, Chicago.

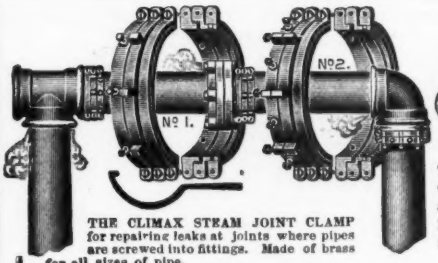
J. B. HACKETT, 5 Temple Court, New York Representative.

WILL YOU CHOOSE CLEAN FLUES



or will you allow the soot to pile up in them?
It all depends upon whether you install the Monarch Steam Flue Blower, a device which sets in the rear wall of the boiler and blows the soot clean out of the boiler *in the direction of the natural draft.* This operation takes but five minutes and never fails to clean. Write at once.

The Monarch Steam Blower Co.
Troy, New York

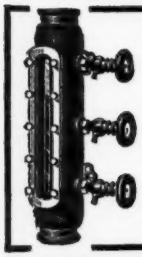


THE CLIMAX STEAM JOINT CLAMP for repairing leaks at joints where pipes are screwed into fittings. Made of brass for all sizes of pipe.

THE EMERGENCY PIPE CLAMP, for repairing splits and rust holes. Made of malleable iron from ⅛ in. to 12 inches.

PIPE REPAIRS FOR ANY CONDITION

Send for Catalog of
STEAM SPECIALTIES
JAMES McCREA & CO.,
MANUFACTURERS,
61 West Washington Street, Chicago.



A PROPER GAUGE FOR SAFETY

The Reliable Water Gauge and Column always dependable.
WRITE.
Reliable Water Gauge Company,
1616B Pine St., St. Louis, Mo.

REMEMBER IT'S THE LITTLE THINGS THAT TELL

Little things like Gilbert Gauge Glass Preservers can save a great deal of time and trouble. No tools required. Shall we send a sample box—60c? CIRCULAR?

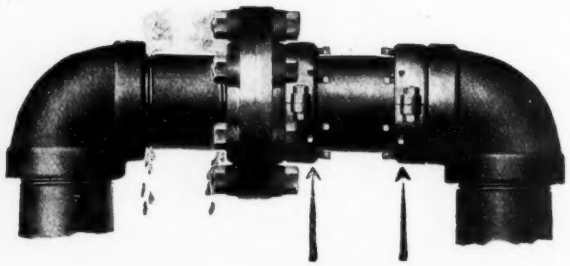
R. F. MORSE, Providence, R. I.

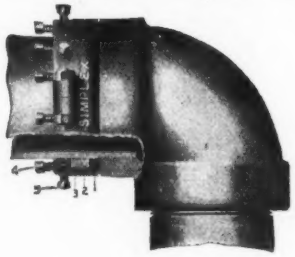
The Best Makers Make The

HERCULES SEAMLESS COPPER FLOATS

The Best Floats Made
Catalog "B"?
Hercules Float Works,
P. O. Box 396, Springfield, Mass.

To Stop the Worst Leak—Free





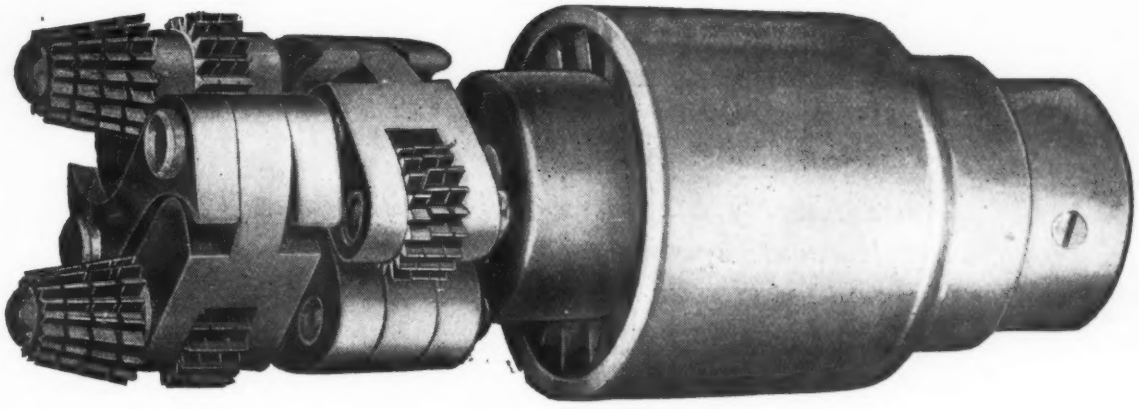
and render the troublesome joint **absolutely** and **permanently** tight, it is only neccessary to apply the Simplex Pipe Clamp. Anyone can clamp it while the pipe is under full pressure. To banish all doubt, we're willing to send one on a 30 days' free trial, returnable at our expense if not wanted. Write for further particulars.

THE SIMPLEX ENGINEERING CO., 316 PRESTON ST., PHILADELPHIA, PA.

"A MOST EXCELLENT DEVICE, THE BEST EVER USED."

That is what the American Spirits Mfg. Co., of Peoria, Ills., told us after three months use of the new

WEINLAND WING HEAD TURBINE CLEANER



We will send you, all charges paid, a cleaner like the one shown above. Try it on your dirtiest boiler, and if you wish, in competition with any other cleaner made. If the results don't indicate exactly what the American Spirits Mfg. Co. say, you don't have to keep the cleaner, nor will the trial cost you one cent.

Remember that our Wing Head is entirely different from all others. More cutters, heavier arms, stronger pins, and the arms are free from that hit and miss jumping around that by its very nature must be so disastrous in other types. The Weinland Wing Arm always swings in ONE plane. A heavy weight is swung hard against the cutters which makes them dig into the scale.

Ask about our new Weinland Steam or Air Driven Mechanical Cleaner. We sell or rent this machine, or will clean your boilers on contract. Write for catalog.

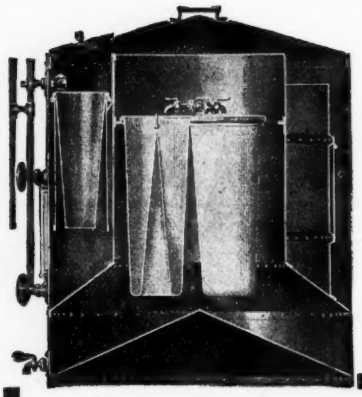
We also make Safety Automatic Cut-Off Valves, Tube Cutters, Reseating Machines. Money savers all.

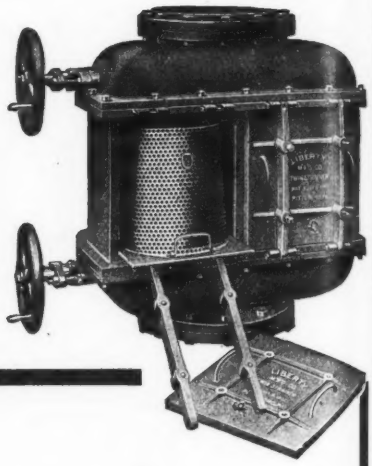
THE LAGONDA MFG. CO., Springfield, Ohio.

New York Philadelphia Pittsburg Chicago San Francisco Birmingham Toledo London

[71]

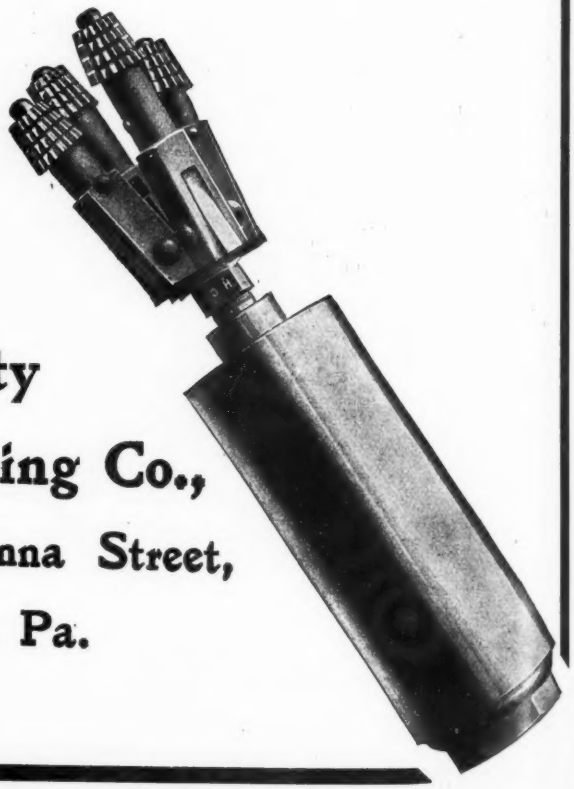
It Is Easier To Keep A Plant Clean Than To Clean It





IF you use Liberty Strainers, Oil Purifiers and Tube Cleaners you will avoid expensive operations on your water mains, save a large percentage of your oil costs and get a great deal more steam from each ton of coal consumed.

We are ready to prove that no other devices of a similar nature can do so much to lighten power plant expense, save the engineer's time and increase the plant's efficiency. Ask for proof.

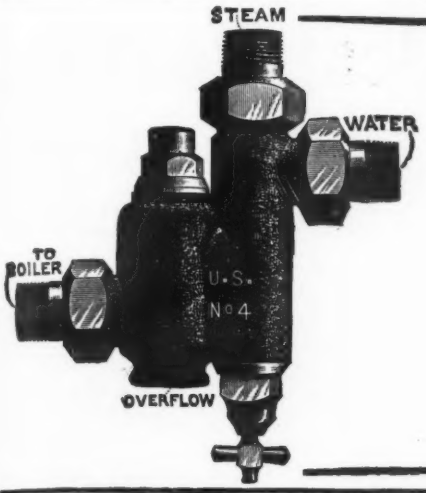


Liberty

Manufacturing Co.,

6509 Susquehanna Street,

Pittsburg, Pa.



U. S. Automatic Injectors have an International Reputation for Superiority.

They have just as firm a foothold abroad as at home. Only genuine merit has placed the "U. S. Automatic" in this position. The more particular you are about securing reliable boiler feeding—the better it pleases us—for we have the **only reliable boiler feeder.**

Send for our Engineers' "Red Book"—it slips right into the vest pocket, small in size, but large in information.

American Injector Company,
Detroit, Michigan.

A Powerful Little Device for Elevating, Conveying and Transporting Liquids—

The Garfield Ejector

Cannot be beat for raising water from deep wells, mines or pits, filling or emptying tanks, raising or transferring liquids, etc.

Note the straight pipe connections making it desirable for elevating water from deep driven or drilled wells.

Positive in Its Work and Nothing to Get Out of Order

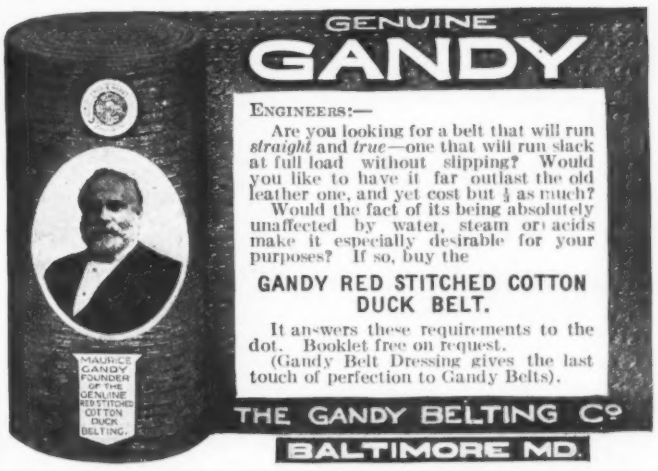
You cannot afford to be without it. Write for complete description. Large Catalog sent free.

The OHIO INJECTOR CO.,
The World's Greatest Injector Manufacturers,
WADSWORTH 110 Main St. OHIO, U. S. A.

A Power Saver

The Akron Friction Clutch allows no power to be wasted. Of all the friction clutches, the "Akron" is the best. It is dependable, durable, easily installed, adjusted and operated. All working parts run in an oil bath. Write for special features of construction

The Williams Foundry & Machine Co.
Akron, Ohio.
Successors to the Akron Clutch Co.



ENGINEERS:—

Are you looking for a belt that will run *straight* and *true*—one that will run slack at full load without slipping? Would you like to have it far outlast the old leather one, and yet cost but ¼ as much?

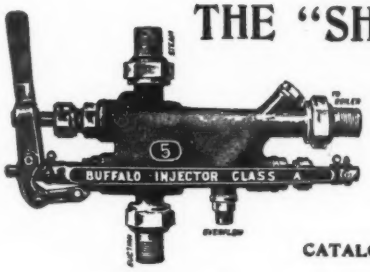
Would the fact of its being absolutely unaffected by water, steam or acids make it especially desirable for your purposes? If so, buy the

GANDY RED STITCHED COTTON DUCK BELT.

It answers these requirements to the dot. Booklet free on request.

(Gandy Belt Dressing gives the last touch of perfection to Gandy Belts).

THE GANDY BELTING Co
BALTIMORE MD.



THE "SHERWOOD" INJECTOR

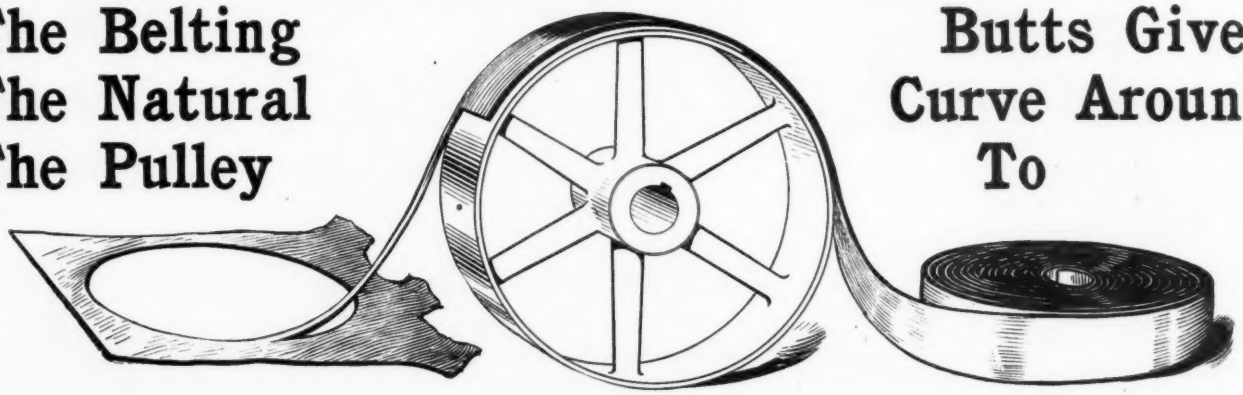
Injectors, Ejectors, Gauge Cocks, Boiler Tube Cleaners, Flue Scrapers and Blowers, Oil Cups and Pumps, Lubricators, Automatic Oil Pumps, Grease Cups, Special Brass Work.

CATALOGUE AND PRICES SENT ON APPLICATION.

SHERWOOD MANUFACTURING CO.,
BUFFALO, N. Y.
Manufacturers of Engine and Boiler Supplies.

THE "HART" OIL PUMP

A Spiral Cut From The Best Part Of The Belting Butts Gives The Natural Curve Around The Pulley To



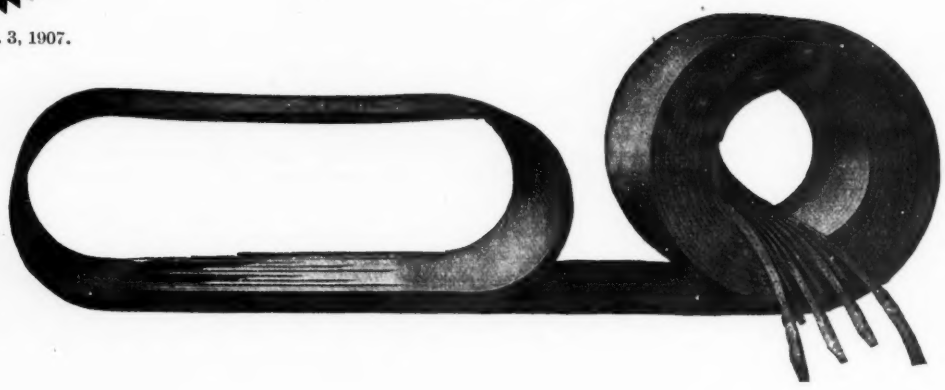
Edge-on

THIS new Laminated Leather Belting solves the positive drive problem by furnishing the one perfect method of efficient belt power transmission. It is cementless, lapless, endless, practically stretchless, and has a natural curve to fit the pulley. "Edge-on" is made of single strips cut spirally from the butt and laminated together. It can be had in any length, any width, any thickness. You don't know what belts can do until you have tried "Edge-on."

Write for Full Information.

PATENT LAMINATED BELT — CEMENTLESS LAPLESS ENDLESS — C CAN'T FAIL F A ANYWHERE

U. S. Patent Dec. 3, 1907.

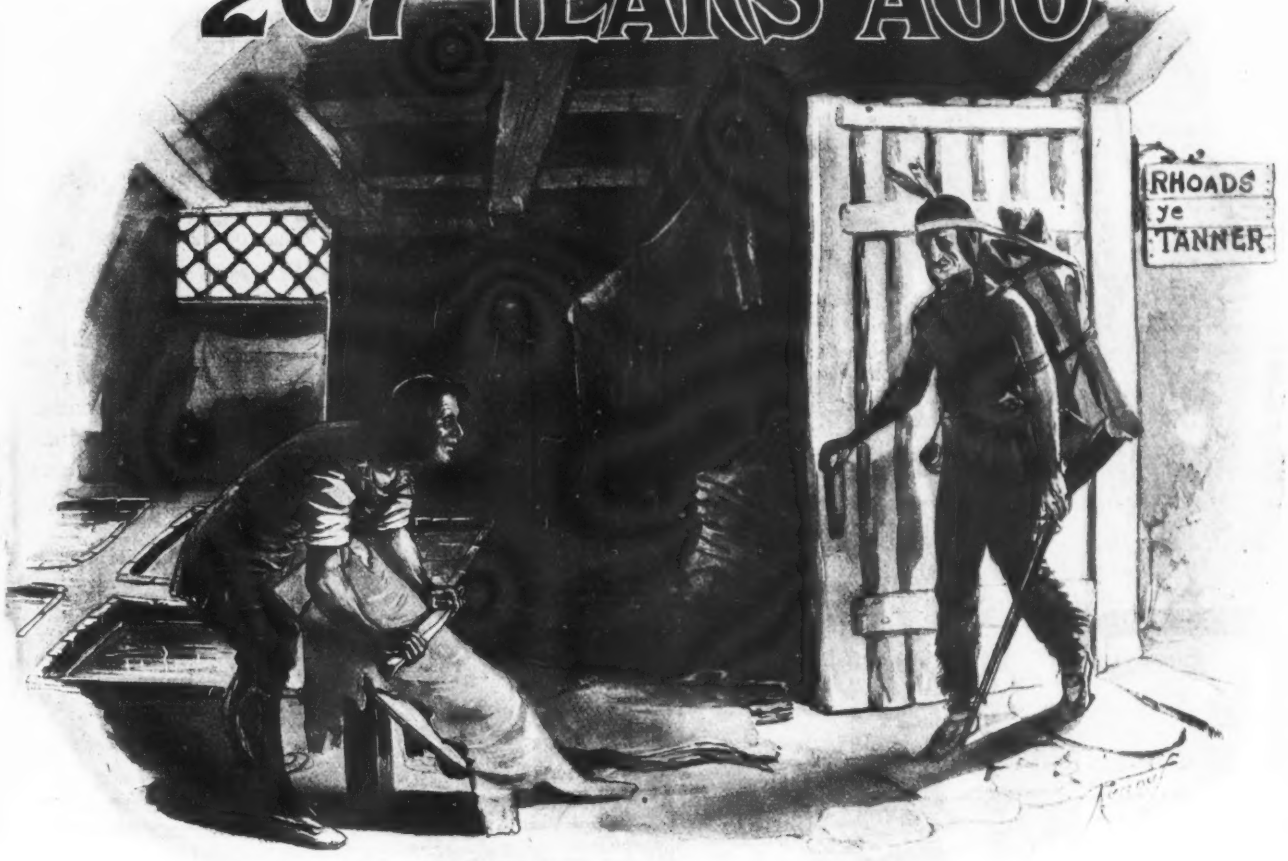


LAMINATED BELTING COMPANY,

Operating under patents granted in United States, England, Canada, Mexico, Spain, France, Belgium, Italy, and other patents in United States and abroad pending.

Chicago Branch, 44-46 Franklin St. 51 BEEKMAN STREET, NEW YORK CITY.

207 YEARS AGO



Philadelphia is celebrating her 225th anniversary. This year is the 207th of the Rhoads leather business in America. Our business has been handed down to us in direct line through six generations of ancestors. In 1699 the first of the six bought a tract of land in Delaware County, Pa., for his son, who in 1701 established a tanyard thereon. The senior member of our firm was the fifth and last in the line to operate this tannery. In 1868 he moved to Wilmington, Delaware.

To the good old ways handed down from the fathers, we have been alert to apply science and experiment and to add such improvements in methods and machinery as stand the test of use. We have a modern factory of large capacity, and the growth of our business makes us confident that our methods, equipment and output will bear comparison. Our constant aim is to produce the best belt at lowest cost consistent with high quality. Those who have for years used it best know the service given by

Rhoads Leather Belting

Let us submit samples and quotations on your needs.

J. E. Rhoads & Sons, Philadelphia, 12 N. Third St.
New York, 40 Fulton St.

Factory and Tannery, Wilmington, Delaware.

C S

Stands for Cling-Surface and Common Sense. Engineers have both.

Haven't you ?

How often do you have to hustle to fix some belt? How often work evenings or holidays? How much general belt trouble, work and worry?

Cling-Surface will end it because Cling-Surface belts are always in vigorous health, pliable and waterproof.

They never slip. Consequently they never run off. They run easy or slack and so never heat bearings. They carry full loads and attend to business and you can depend on them just as you can on yourself.

The common sense you've got. Get the Cling-Surface, for we guarantee these results. Get it now.

Write us.

Cling-Surface Company

1049 Niagara Street Buffalo N Y

New York Boston Denver Atlanta
Chicago St Louis St Paul Memphis etc

London Thomas & Bishop 119-125 Finsbury Pavement E C

Use Sable Belting On Your Hardest Drive.

Where the belt must run at high speed over small pulleys, **Shultz Sable Rawhide Belting** is the cheapest because

It saves buying belt dressings,
It saves the time of men and machines,
It saves more power, and
It saves bearings and belts,

as compared with belts that must be tightened with every change of weather, or those which must be replaced at short intervals because of their non-durability due to being run too tight.

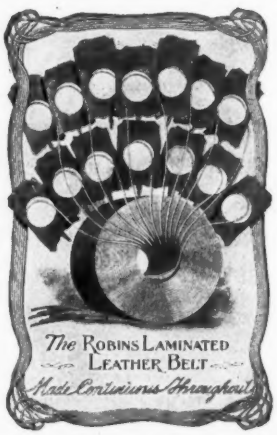
Other facts in our Belt Book "No. 4." When you need a belt let us send you a **Shultz Sable Rawhide Belt** for a month's free trial.

SHULTZ BELTING COMPANY,

St. Louis, Mo.

NEW YORK BOSTON PHILADELPHIA

30



Practically Akin to a Positive Drive

ROBINS LAMINATED LEATHER BELTING

The only logical choice between direct connection and the belt.

Indispensable for High Speed Heavy Duty Service

Made from continuous units cut in strands of full roll length from the finest selected oak tanned belting butts. The strands are cut to gauge and the width determines the thickness of the belt when they are laid on edge and laminated together. Every strand is stretched independently to the full elastic limit guaranteeing a belt which is practically *non-stretchable*. **NO LAPS, NO PLIES. NO CEMENT**—joined endless upon the pulleys with a neat and simple splice which holds the gauge, balance and strength of the belt intact.

WRITE FOR CIRCULAR No. 2.

ROBINS NEW CONVEYOR COMPANY

Factory : 168 Duane St., New York.

New York : 38 Wall St. Chicago : Old Colony Bldg.

American Pulleys

have secured such a high standing that *over a million* are in daily, active use.

They are safe, light, practically indestructible and fit shafts of various sizes. Sold by supply houses everywhere.

Shall we send you our booklet?

Patented in the United States and foreign countries.

THE AMERICAN PULLEY CO.
28th and Bristol Sts., Philadelphia, Pa.

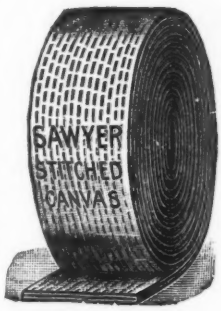
Jeffrey "Century" Rubber Belting

Conveys Material in Both Bulk and Package Form.

Illustrated catalogue No. 67A free with Elevating, Conveying, Crushing, Screening, Mining, Drilling Catalogues.

The Jeffrey Mfg. Co.,
Columbus, Ohio, U. S. A.

BRANCHES: New York, Chicago, Boston, St. Louis, Denver.



Belting Logic—If best Leather Belting costs per sq. ft. $.00, best Rubber Belting 60c., and best Stitched Canvas Belting 40c., and with Leather showing 25% and Rubber 50% of the strength of **Best Stitched Canvas Belting,** wouldn't it be good policy for you as a practical man to investigate the merits of our product? Send for Book "C".

Sawyer Belting Co.,
Cleveland, Ohio.

Get The Habit
OF USING
The Hercules Leather Pulley Cover

and you will entirely eliminate your belt troubles. **Our Hercules Leather Oil** will preserve your belts and keep them soft and clean. Never use belt dressings of any kind—they are injurious to leather.

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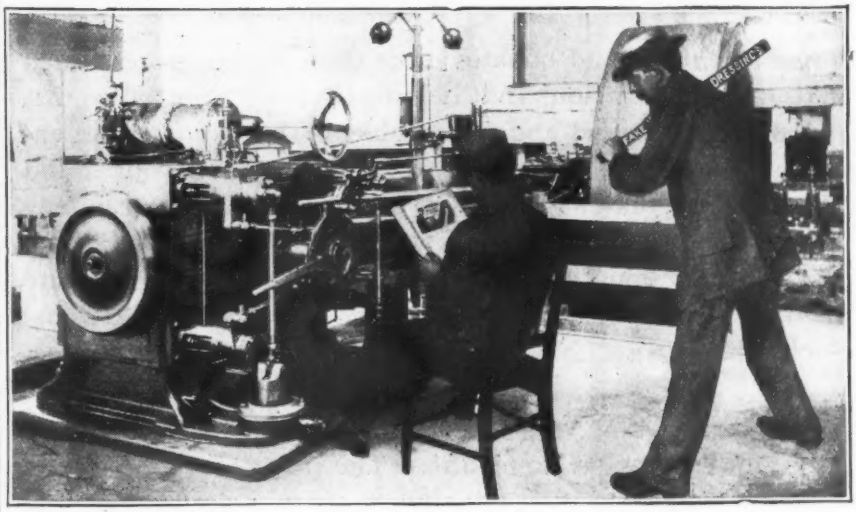
HERCULES PULLEY COVER CO.
DETROIT, MICHIGAN.
Manufacturers of Leather Pulley Covering.

DON'T BE SAND-BAGGED



DON'T let some slick tongued fellow make you pay for ruining your own belts. **You know** that resin does your belts no good; you know that tallow and lard are not worth much for belt dressings; don't buy them then just because they are put up in an attractive package and labelled "Belt Dressing."

Get acquainted with **OXoilOX,** pure Neatsfoot Oil refined and improved so that it preserves and strengthens belts.

OXoilOX doesn't make belts sticky. It isn't a dope—it's a belt food, that keeps belts **soft** and **tough** and **clean.** Belts treated with **OXoilOX** cling to pulleys so closely that air is absolutely excluded, and the vacuum thus formed prevents slipping, and enables belts to **run slack** at full load.

Our booklet tells how **OXoilOX** was discovered—you'll be interested; mailed free on request.

A FREE SAMPLE

F. S. WALTON CO., Philadelphia, Pa.

Gentlemen: Kindly send us, free of charge, a sample can of OXoilOX the Perfect Belt Dressing.

Name..... Address.....

Name of Firm..... Number of Belts..... Average Size.....

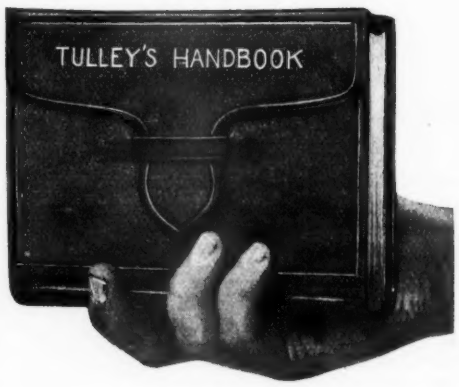
F. S. WALTON CO., Philadelphia, Pa.
Pressers and Refiners of all grades of Neatsfoot oil.

Tulley's Handbook

30,000 engineers have bought Tulley's Handbook. For fun? For entertainment? No! For business! For the practical facts on its pages; for the help it gives in the day's work

It Does

what no other book on earth does — it covers the whole field of steam and electrical engineering clearly, plainly, practically, concisely. It deals in facts and figures that every engineer should know or have close at hand for reference.



It Does Not

talk in foggy language. It does not include any foolish theories. It does not contain algebra, Latin, Greek nor the 'ologies nor 'isms. It does not shoot over the heads of practical engineers.

Picture in your mind a fine leather bound book of more than 1,000 pages, each page chockful of useful information or illustrations that help to clear up knotty points. Imagine yourself up against one of the thousand and one problems that confront an engineer, or with the license examination facing you, or with something in your mind upon which you want special information that will enable you to save time and money or promote the efficiency of your plant. Picture yourself with Tulley's Handbook within reach when those points come up. Do you know that you can turn to the complete index, find your subject and then be assured of finding complete and authoritative information upon *your* problem? Such a book *must* hold a value for you far beyond its price.

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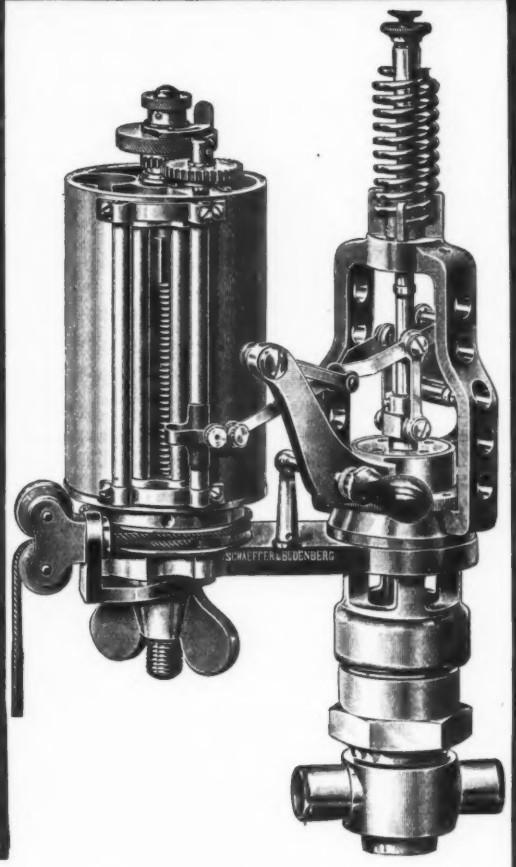
Hill Publishing Co., 505 Pearl St., New York



The Tried And Trusted Thompson

Indicator with outside spring and continuous diagram is the indicator for **you.**

Because:—

It takes a strip of paper 6 feet long. Roll can be detached without disturbing indicator. It is always absolutely reliable, and cool in use.

There are many other reasons why the "Thompson" is the finest and most accurate instrument of its kind in existence.

Write for full particulars.

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Main Office and Works:
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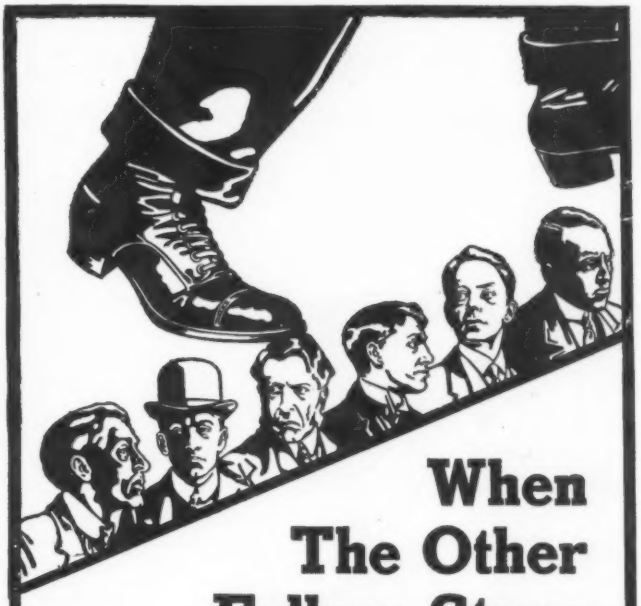
Western Salesrooms:
15 W. LAKE STREET, CHICAGO.



When The Other Fellow Steps Over Your Head

Yes, it does jar you to have some other fellow step over your head and take possession of the job you've had your eyes on for some time—to say nothing of money that goes with it.

But why does this happen?

A little thinking brings you face to face with the undeniable fact that **training** is responsible for it—that while you were **waiting** for opportunity, trusting to luck for promotion, the other chap was **making** his opportunities by preparing himself for positions ahead.

To advance you must have the practical training that makes you an expert. No man can expect to get a higher position if he has not the ability to competently hold that position.

I. C. S. Trained Men Win

The I. C. S. brings a six-million-dollar equipment and an experience of nearly 17 years in the sole business of salary-raising training to the personal advancement of every one of its students. It assists these men in their own homes, in their spare time, and at a cost arranged to suit their own individual circumstances. It overcomes all obstacles of lack of time, money, or education, and secures for poorly paid wage earners such advancement as they never even hoped for before. What the I. C. S. has done for thousands of other men it can do for **YOU.**

Without any cost to you the I. C. S. will tell how **you** can get in line for promotion. Simply mark the coupon below and mail it. **Initiative wins—mark and mail this coupon NOW.**

International Correspondence Schools
Box 979, Scranton, Pa.

Please explain, without further obligation on my part, how I can qualify for a higher salary and advancement to the position before which I have marked X.

Electrical Engineer	Machine Designer	Sanitary Engineer
Elec.-Light. Supt.	Mechan'l Drafts'n	Architect
Elec.-Rail'y Supt.	Foreman Machinist	Architect'l Drafts'n
Electrician	Foreman Toolmaker	Ad Writer
Telephone Eng.	Foreman Molder	Window Dresser
Civil Engineer	Foreman Blacksmith	Chemist
Bridge Engineer	Marine Engineer	Sheet-Metal Draft.
Mechanical Eng.	Hydraulic Engineer	Ornament. Designer
Stationary Eng.	Municipal Eng.	Textile Designer
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Traction Eng.	Mining Engineer	Civ. Service Exams.

Name _____

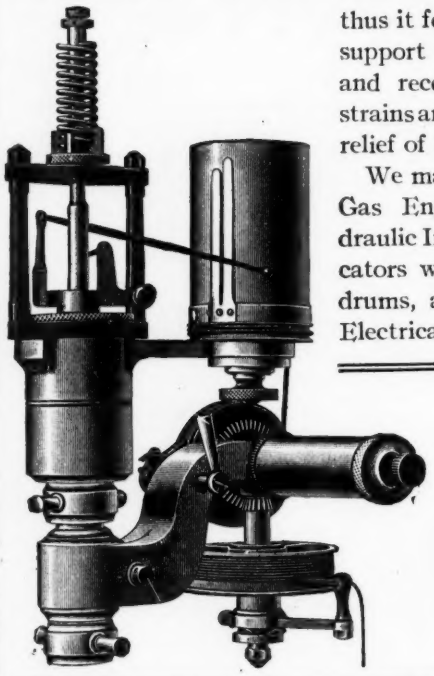
Street and No. _____

City _____ *State* _____

THE REDUCING WHEEL HOLDS THE INDICATOR

thus it forms a base or support for the latter, and receives all the strains and shocks to the relief of the indicator.

We manufacture also Gas Engine and Hydraulic Indicators, Indicators with continuous drums, and Sargent Electrical Attachments.



Catalog?

TRADE MARK ☆ CROSBY ☆

CROSBY STEAM GAGE & VALVE CO.

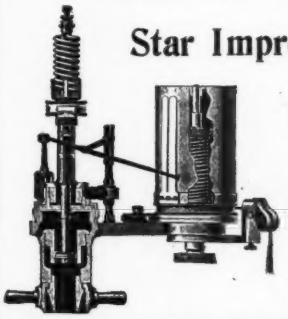
Boston. New York. Chicago. London.

A PERFECT INDICATOR

IS THE

Star Improved Outside Spring

Class B Style.



Suitable for.....
High Pressures,
High Speeds,
Superheated Steam,
and all uses where absolute accuracy is required.

A QUALITY INSTRUMENT.

Send for Circular.

Manufactured Exclusively By

Star Brass Mfg. Co., 108-114 E. Dedham Street, **Boston, Mass.**

ECONOMICAL BRILLIANT

U.S. METAL POLISH

G. W. Hoffman, Sole Prop. 295 E. Wash. St. INDIANAPOLIS, IND.

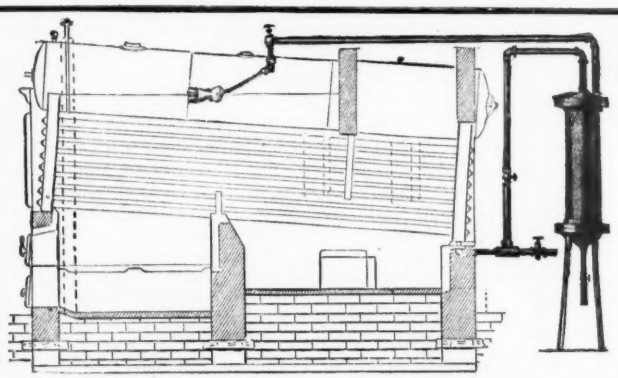
TRADE MARK

INFALLIBLE

FOR POLISHING GOLD, SILVER, PLATED WARE, NICKEL, TIN, BRASS, COPPER, Etc.

DIRECTIONS:
Take a little of the Polish on a soft cloth, rub the Metal hard and then wipe it off with a dry cloth.

LASTING AT ALL DEALERS



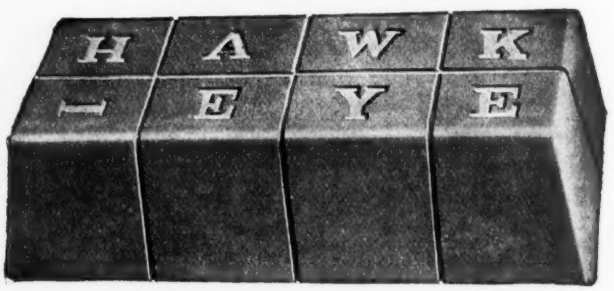
Its Use While on Trial Will Pay Its Cost

You will save the cost of boiler compounds or mechanical cleaners and the time required to use them. You will also save the tubes which would be damaged by cleaners and compounds. Write for catalog and estimate. 30 days' free trial.

BUCKEYE BOILER SKIMMER CO., South End, Toledo, Ohio.

The Hawk-Eye Is The Only Boiler Compound Company

All other firms deal in other articles.



Eight one-pound squares in every block.
There is no acid in our compounds.

If a physician attempted to plead a law case in court he would be called a Jack of all trades and those who are engaged in all kinds of business and at the same time attempt to manufacture boiler compounds are Jacks of all trades and Masters of none.

After you have grown tired of spending money with that class, send us an order and you will not regret it.

Hawk-Eye Compound Company

303-304-305 Merrick Block, CHICAGO, ILL.

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HARRIS

TRADE MARK REGISTERED

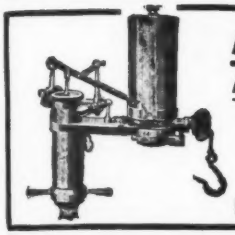
OILS

For outside moving parts of engines and all principal transmissions

USE HARRIS ENGINE OIL.

Has excellent body. Possesses a high fire test. Will flow freely in cold weather. Filters well. Specify HARRIS OILS in your requisitions.

A. W. Harris Oil Company,
323 So. Water St., Providence, R. I.



A Standard Indicator

At $50 Under The Standard Price

To prove this claim we send a Trill for ten days' trial free of charge. Catalog?

THE TRILL INDICATOR COMPANY
Eagle Street CORRY, PA.

PURE WATER FOR THE BOILERS BY THE

WE-FU-GO and SCAIFE

Water Softening and Purifying Systems.

RESULTS GUARANTEED SEND FOR OUR CATALOG.

WM. B. SCAIFE & SONS CO.,
Founded 1802. PITTSBURG, PA.

BIRD-ARCHER BOILER COMPOUNDS

I used to wear over-alls three Sundays out of the month trying to keep down the scale and grease in our boilers, but I've quit working overtime.

Nosir, there's no use in worrying with leaks and cleaners, the right way to clean boilers is to use **Bird-Archer Compound,** because it's easy to handle and guaranteed to do the trick. If it doesn't cut out the scale and grease and stop pitting and grooving you don't have to pay for it.

Better ask for their Book, "Boiler Troubles and their Prevention."

THE BIRD-ARCHER CO.,
90 West Street, New York City.

4-A

Rx

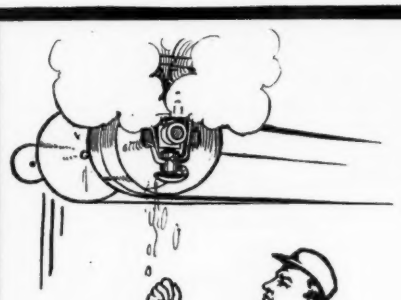
We treat your boilers for scale formation just as a good doctor treats disease in a patient.

First a careful diagnosis gained by chemical analysis of feed water.

Then a prescription prepared for the individual case, ready for use with nothing for you to do but inject as directed.

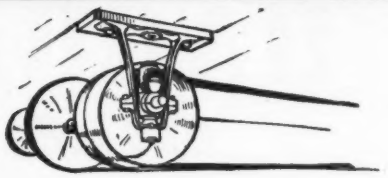
We go anywhere for business. Some good territory still open for ambitious salesmen of the $5000 class.

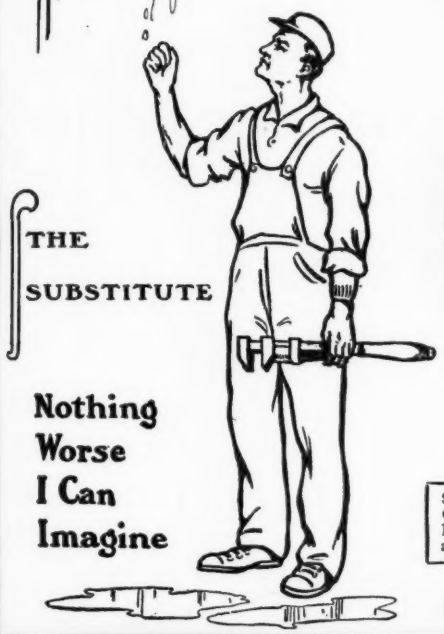
Binghamton Boiler Compound Co.
Binghamton, N. Y., U. S. A.



THERE IS ONLY ONE

ALBANY GREASE





THE SUBSTITUTE

Nothing Worse I Can Imagine

The only Genuine ALBANY GREASE has this trade mark on every package. Look and ask for it.

Send for FREE sample cup and can of "Albany Grease," giving size of tap for cup, depth of oil hole from top of cap to journal, where to be used and firm's name.

MADE ONLY BY
ADAM COOK'S SONS,
313 WEST ST., NEW YORK.

NOTHING EASIER

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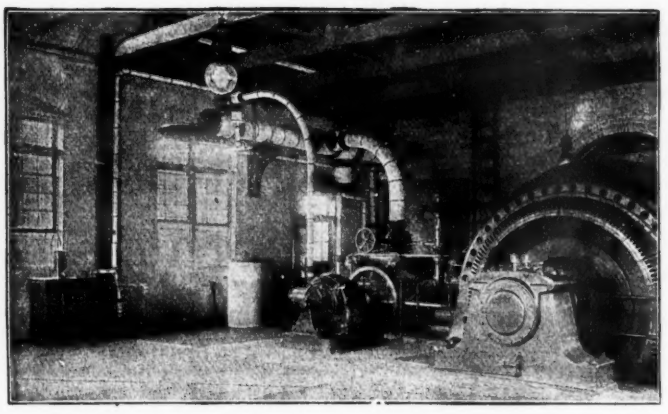
THE ONLY GENUINE.

Engine Oiling In The Modern Power Plant



Down in what most people regard as the wildest part of south central West Virginia, in the territory from which some of our finest smokeless fuels are secured, is the McKell Coal & Coke Co., Glen Jean, W. Va., operating collieries scattered at convenient points over a tract of several thousand acres. Electric power for operating these numerous scattered mines is supplied by an alternating current system of distribution from a central power plant. High-tension alternating current is transmitted from the central station to scattered substations, where it is transformed and converted into low-tension continuous current for use at the adjacent mines.

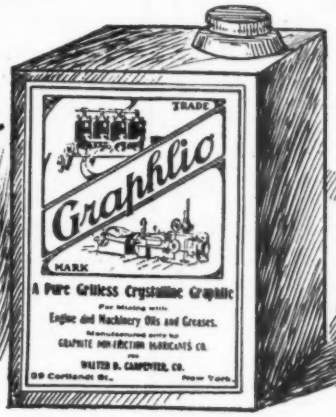
The illustration shows the first 500-k.w. alternating current generating unit in the power house, which provides space for installation of a duplicate unit. At the left may be seen the Duplex Type White Star Oil Filter and circulating pump of the White Star Continuous Oiling System here in use for lubricating all the engine bearings. Overhead, out of sight among the roof trusses, is a reservoir from which the oil is piped to feeds fitted to all the bearings on the engine. All oily drips from the various bearings are drained to a tank beneath the engine room floor, from which they are lifted automatically to the White Star filter on the engine room floor. After being thoroughly cleaned in the filter, the oil is pumped back to the overhead reservoir, ready for use again. Thus there is a constant stream of oil fed to all bearings, amounting in this case to a circulation of about 200 gallons per day. The reservoir is so arranged that any excess pumped to it would be returned through automatic valves to the filter.

By use of the White Star continuous oiling system the bearings are all supplied with a copious flood of oil, affording that generous supply which is known to be necessary to perfect lubrication, yet *absolutely without waste*, since not a drop of oil can escape from the system, except as it is actually worn out in the bearings.

We are prepared to equip power plants of any size contracting to furnish the necessary apparatus or erecting such outfits complete. Our catalog "D" treats fully on this subject. Send for it.

Pittsburgh Gage & Supply Co., Pittsburgh, Pa.

GRAPHLIO



CUTS YOUR OIL BILLS IN (½) HALF

GRAPHLIO is a perfectly pure Crystalline Graphite product reduced to an impalpable powder and absolutely gritless. When mixed with your oil, in the proportion of about 1 to 200, the efficiency of the oil is practically doubled, as innumerable tests have proved.

It Remains In Suspension

In Any Kind Of Oil

GRAPHLIO can be used with perfect safety in any continuous oiling system without change of cups, lubricators, etc., nor affecting the efficiency of the filter.

Under high pressures, speeds and temperatures GRAHPLIO is especially effective. It is not affected by heat, gases, alkalies, acids or ammonia.

Let us prove to you that GRAPHLIO will save 40 to 60% of your oil bills. It's something you need in your business.

Walter D. Carpenter & Co.,

39 Cortlandt St., New York, N. Y.

ANTI-CORROSIVE CYLINDER OIL
MANUFACTURED ONLY BY E. H. KELLOGG & CO. 243 & 245 SOUTH ST. NEW YORK, U.S.A.

The OIL That LEADS THE LIST.

There are other cylinder oils whose initial cost is less than "Anti-Corrosive," but invariably they prove more expensive in the end.

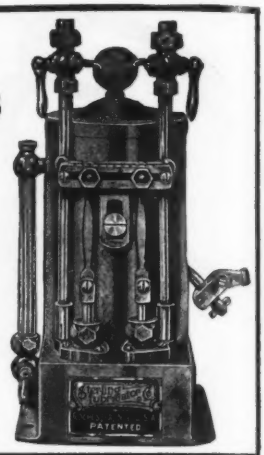
Glib salesmen have occasionally persuaded some of our customers to try their "low priced oils" with the result that the duped concerns have gone back to "Anti-Corrosive" in a hurry.

We'll send you a barrel for a 90-days' trial. If you think it's worth our price, "pay up." If you don't like it, pay any price you please and get our willing receipt in full. Write.

E. H. KELLOGG & CO.,
243 South St., New York City.
8 B Rumford Court, Liverpool, Eng.

Feed Your Engines & Pumps

with just the right amount of oil and you will get the most satisfactory results. The Sterling Force Feed Lubricator does just that, and does it so efficiently that $\frac{2}{3}$ to $\frac{3}{5}$ of the oil is saved. Try one for 30 days, free.



CATALOG ?

Sterling Lubricator Co.
3 Frank St., Rochester, N. Y.

A Little Graphite Saves A Lot of Oil

By filling up the inequalities, of the rubbing surfaces, Dixon's Flake Graphite reduces the oil or grease bills to the lowest possible terms.

WRITE FOR FREE SAMPLE 94-C

JOSEPH DIXON CRUCIBLE CO.
JERSEY CITY, N. J.

TRADE MARK NON-FLUID OILS REGISTERED IN UNITED STATES PATENT OFFICE

TRY NON-FLUID OILS FREE

Lubricants that make three wipings necessary to every application aren't economical or desirable. Ordinary oil is naturally sloppy and the heat around an engine quickly changes grease from solid to fluid. Either will let the bearings run dry, will flow over the outside and get slung from the fly-wheel.

NON-FLUID OILS are the most cleanly, most efficient and most economical engine and shafting lubricants on the market.

In addition to outlasting oils or greases, NON-FLUID OIL prevents wear and tear better, thus will insure most efficient service from your engine, low repair and lubrication bills.

Made in 40 different grades, covering every service.

Get a free sample which will prove our claims.

ORIGINATORS AND SOLE MANUFACTURERS.

NEW YORK AND NEW JERSEY LUBRICANT CO.
Dept. A., 14-16 Church St., New York.

10

THE MODEL "M" METHOD

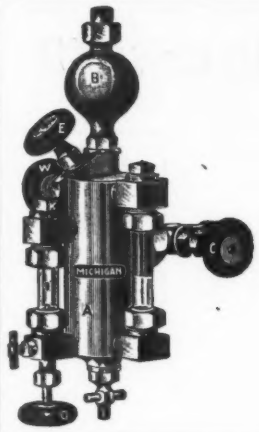
YOU know that the most economical and perfect lubrication is secured by an automatic oil pump that positively delivers small quantities of oil to the steam at very frequent intervals.

Tool steel polished plungers, hardened check valves, adjustable metallic packing, and other refinements of construction are a part of the interesting details of Model "M."

The Model "M" Method! Do you know about it? Told in Bulletin No. 109 E.

MANUFACTURED BY

SIGHT FEED OIL PUMP CO.
MILWAUKEE, WIS., U. S. A.



Michigan Lubricators

ENGINEERS

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MICHIGAN LUBRICATOR COMPANY

DETROIT, MICHIGAN

Detroit Improved Standard Lubricator

Some One

of our 337 different styles and sizes of sight-feed lubricators will fill any requirement you may have.

When ordering, insist on getting the genuine Detroit.

Write for a catalog of the most complete line of oiling devices for all purposes.

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Automatic Lubricators

when ordering your NEXT engine.

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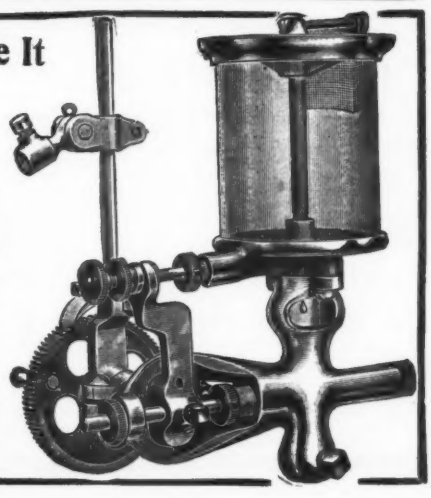
GREENE, TWEED & CO.
109 Duane Street, NEW YORK.

You'll Believe It When You See It



You can see at a glance that **Manzel's Force and Sight Feed Lubricator** can't help working properly if it is properly attached.

Write today.

Manzel Bros. Co.,
326 Babcock St.,
Buffalo, N. Y.

Analysis of Lubricants Specifications for Oils

Inspection and reports on lubricating conditions to show where economies can be made and costs reduced.

WILLIAM M. DAVIS, Lubrication Engineer
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Send for Nugent's Valuable Treatise on HOW TO OIL AN ENGINE and large catalog No. 7 A of new and Up-to-date Oiling Devices for Hot Members

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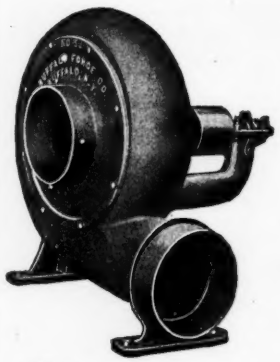

7 Ex.

Buffalo B. Volume Exhausters

are especially adapted for exhausting hot air from Boiler and Engine rooms when air is to be delivered through piping or against any resistance.

Booklet PR on request.

BUFFALO FORGE CO., - Buffalo, N. Y.

CANADIAN BUFFALO FORGE CO., Ltd., Montreal

Steel Pressure Blowers for Cupola and High Pressure Blast Service.
"B" Volume Blowers for Forge Shops, Forced Draft, etc.

The First Aid to Lubrication–

"TACOMA"

of Engine or Machinery bearings should be a first-class Oil Cup. It should be of substantial construction—easy to regulate—should maintain a predetermined and constant rate of feed without waste, and without any liability of the feed adjustment becoming disarranged by jarring or vibration.

Williams Oil Cups

meet these demands perfectly. They are compact, finely finished and are made by experts who "know how" because they have had experience in this line covering a period of more than a score of years. Williams Oil Cups are made in great variety sufficient to meet every lubricating need.

Consult us on lubrication matters. One of these devices may save you considerable annoyance and enable you to forget many lubricating ills.

Write for Williams Oil Cup Booklet.

THE D. T. WILLIAMS VALVE CO.
904-910 BROADWAY, - CINCINNATI, OHIO

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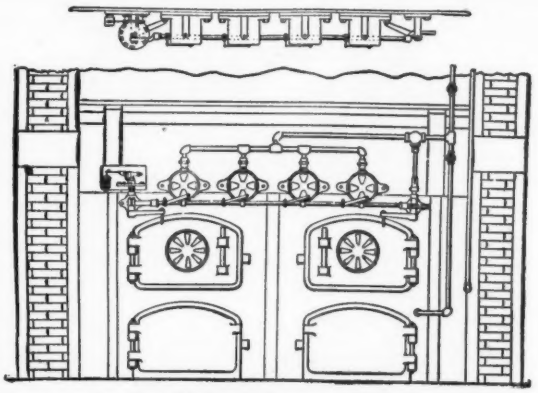


Control The Smoke Formation

in the furnace of your boiler by means of our new and improved system of regulating the air and steam supplies. The whole mechanism is very simple and easy to install. It is operated by a timing arrangement, and controlled by an eight-day clock movement. The steam and air are shut off the instant the fireman opens the door. Absolute harmony between the clock and the boiler front.

Let us tell you how you can reduce your fuel bills.

Climax Smoke Preventer Co.,
205 Equitable Building, BOSTON, MASS.

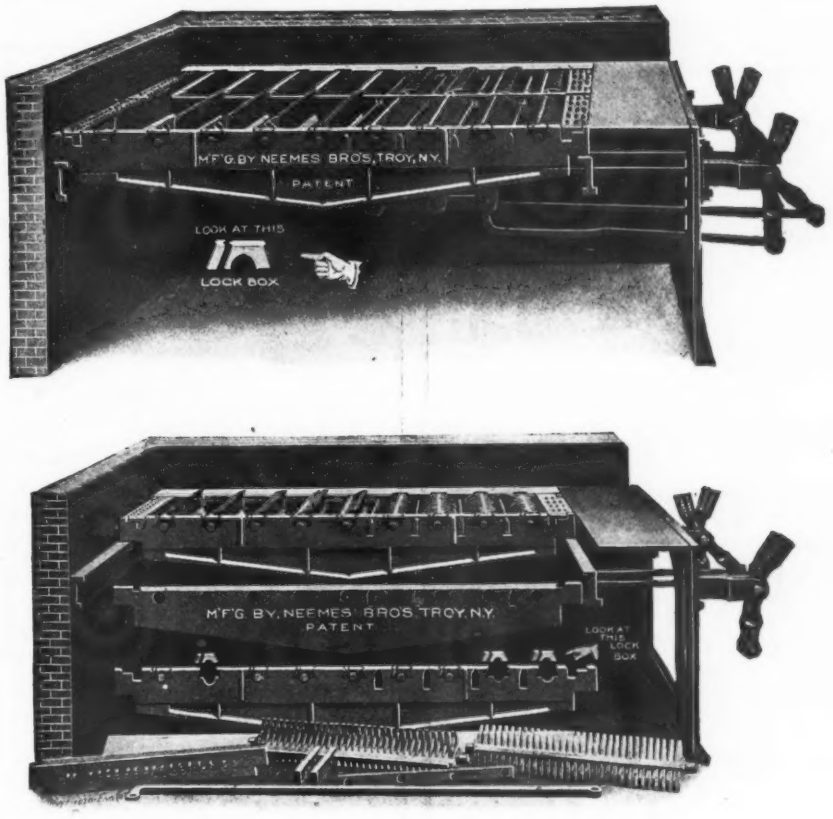
Cheap At Double The Price

As compared with any other filter made the Acme will deliver more clear lubricant, require less attention and although it costs no more than others, it would be cheap at double their price. Write.

Walter L. Flower Steam Specialty Co.,

311 So. 8th St., St. Louis, Mo.

Clinker Cutting Shaking and Dumping



THE ONLY GRATES THAT WILL PERFORM THESE OPERATIONS

are the **Neemes Bros.' Improved Grates,** Shear Cutting Shaking Grate Front and Shaking and Dumping Grate Back.

Plants in which they are installed, are operating at *less cost* than formerly, because a much cheaper grade of fuel can be burned.

And note: A slight agitation of the lever shakes out the *ashes* only; a full opening and a few shakes dumps the entire contents of the grate into the ash pit.

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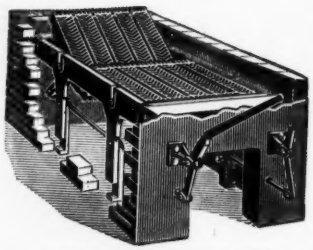
Manufacturers of Square and Round Grates.

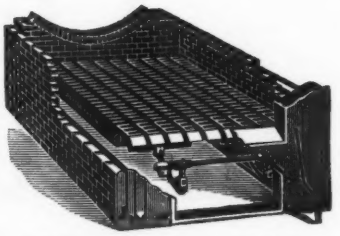
C. W. Van Blarcom, Hudson Terminal Bldg., No. 30 Church St., Agent for New York City and vicinity. Babcock & Wilcox, Ltd., Montreal, Canada, Sole Makers for Canada. Burke Engineering Co., 311 Industrial Building, Providence, R. I., Sole Agents for the New England States. Cass Harkins, Hayden Building, Columbus, Ohio.

It's Wiser And Cheaper To Buy A Good Grate



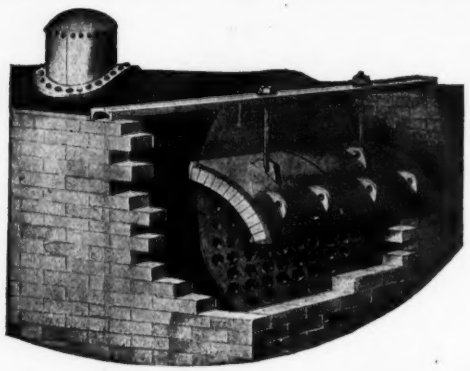
SALAMANDER DUMPING GRATE.

than to waste so much money on coal. The Salamander Dumping Grate and the Aetna Shaking Grate are great coal savers. Write us regarding your conditions and we will guarantee to install a grate that will do better work for you with cheaper fuel and less of it.



THE ORIGINAL ÆTNA SHAKING GRATE.
60 Per Cent. Air Space.

SALAMANDER GRATE BAR CO. Telephone, 4136 Cortlandt. **126 LIBERTY ST., NEW YORK.**



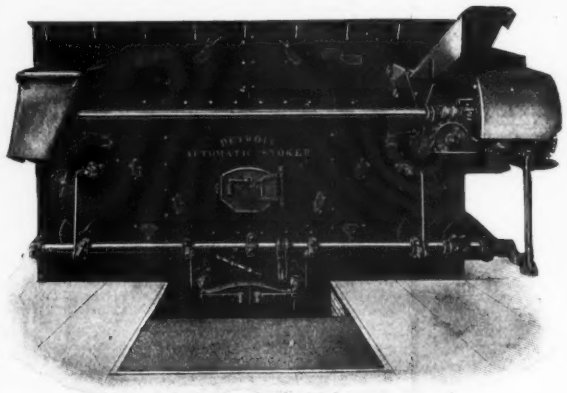
PLENTY OF ROOM UP FRONT

Install the Monarch Boiler Arch and stop crowding the back wall.

No chance of crowding out the brick from the rear wall by the expansion of the rear part of the boiler. The "Monarch" hangs from above and is a "cinch" to set, remove or reset. Money back if you don't like it.

BOOKLET?

MAYVILLE SPECIALTY M'F'G CO.
MAYVILLE, WISCONSIN



"The most economical method for Burning fuel in Power Plants."

Detroit Automatic Stoker

It burns all kinds of coal economically, reducing the fuel bill 10 to 25%.
It adds to the steaming capacity without injury to the boiler shell or tubes.
It feeds and burns the coal and cleans the fires with closed doors.
It insures uniform furnace temperature by continuous, positive feed for fuel.
It does all this with a SMOKELESS STACK.

Send for Catalog.

DETROIT STOKER & FOUNDRY CO.
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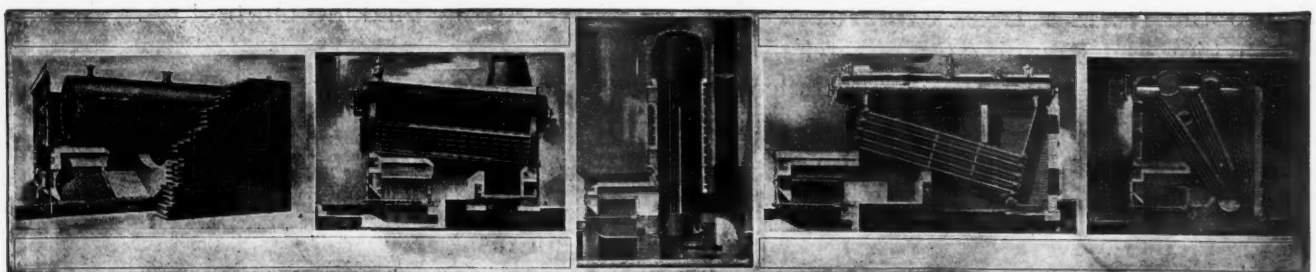

Any type of boiler.

The Murphy Automatic Smokeless Furnace

burns slack and other low cost fuels with unexcelled economy and absolute smokelessness. Strictly automatic in feeding and distribution of coal and the removal of the ash. Send for a complete description.

Murphy Iron Works, 5 Walker Street, Detroit, Mich.

Units of any size.

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MECHANICAL DRAFT

is the order of the day. The fan is positive in action, and independent of wind or weather. It furnishes the necessary draft whenever there is sufficient steam pressure to operate the fan engine.

Includes the MOST EFFICIENT Fan in the WORLD.

STURTEVANT Engines are Specially Designed for the Fan.

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General Office and Works, Hyde Park, Mass.

NEW YORK PHILADELPHIA CHICAGO CINCINNATI LONDON

Designers and Builders of Heating, Ventilating, Drying and Mechanical Draft Apparatus; Fan Blowers and Exhausters, Rotary Blowers and Exhausters; Steam Engines, Electric Motors and Generating Sets; Pneumatic Separators, Fuel Economizers, Forges, Exhaust Heads, Steam Traps, Steam Turbines, etc. 639

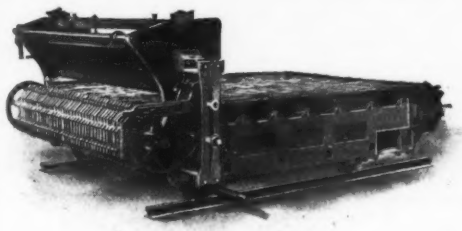
A DARK CLOUD

of smoke hanging over your plant is a positive indication that for every $100 worth of coal burned, from $5 to $15 worth goes up your chimney as waste fuel.

The Wilkinson Automatic Stoker and Smoke Preventer turns this dead loss into live profit. Let us tell you **how** in detail.

The Wilkinson Manufacturing Company,
BRIDGEPORT, MONTGOMERY COUNTY, PA.

GREEN CHAIN GRATE STOKERS



Highest Capacity
Highest Efficiency
Automatic
Smokeless
Labor Saving
Cheap Fuel

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Main Office: Commercial National Bank Bldg., Chicago, Ill.
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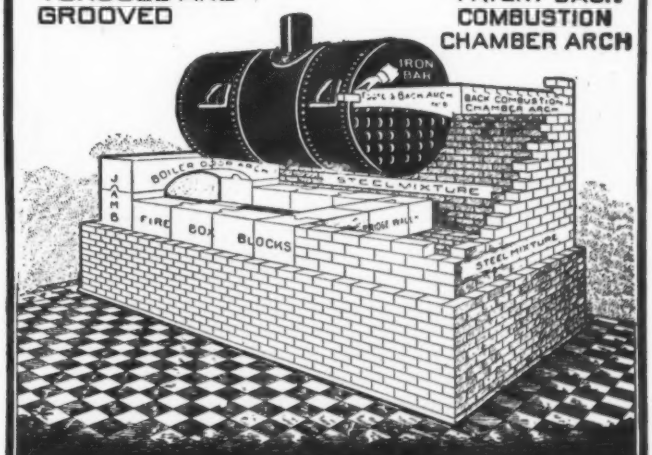
"STEEL MIXTURE"

BOILER DOOR ARCHES AND FIRE BOX BLOCKS

TONGUED AND GROOVED

PATENT BACK COMBUSTION CHAMBER ARCH



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TROY, N.Y., U.S.A.
BRANCH OFFICE, 1402 BROADWAY, NEW YORK CITY.

IT'S LITTLE

But it **DOES** save steam.

All **GEIPEL STEAM TRAPS** are carefully tested before leaving the factory.

WRITE FOR CIRCULARS.

JOHN PLATT & COMPANY,

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STEAM PIPE COVERING

Magnesia, Asbestos, Air Cell,
Wool Felt, Hair Felt, Mineral Wool.

Estimates given and work executed promptly.

ROBERT A. KEASBEY COMPANY,

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C-O-Two Furnace Tile

The best fire arch making material ever devised. Lasts longer. Increases combustion. Write for full description.

C-O-Two Furnace Co., Syracuse, N. Y.

Nason Steam Traps

"SIDELUG" TRAP
(Patented)

THE STANDARD FOR SIXTY YEARS!

Adapted for all conditions requiring the removal of condensation without loss of steam.

SPECIFY:

"CLASS B"—For pressures under 20 lbs.
"CLASS C"—For pressures between 20 and 70 lbs.
"SIDELUG"—For pressures higher than 40 to 150 lbs.

Send for Catalog.

NASON MFG. CO., NEW YORK.

COES IMPROVED COMBUSTION AND DRAFT SYSTEM

GEO. H. THACHER & CO.,
ALBANY, N. Y.

GRATES OF ALL KINDS. BOILER CASTINGS.

We can elevate or convey your **COAL** a distance of 100 feet for less than **ONE CENT A TON**
in quantities of ONE TON A MINUTE or more.

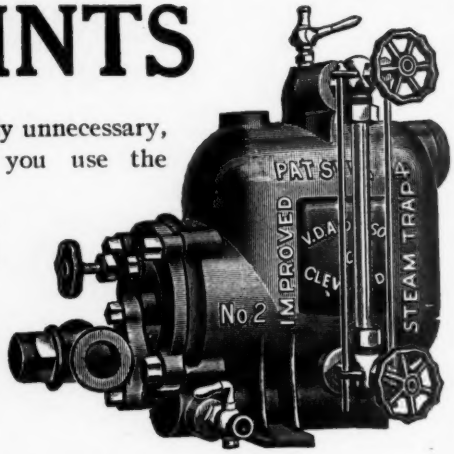
Catalog Free.

THE C. O. BARTLETT & SNOW COMPANY,
Cleveland, Ohio.

DISLOCATED JOINTS

are entirely unnecessary, provided you use the

Anderson Improved Steam Trap.



You can remove the valve seat from the outside without breaking a steam joint or pipe connection.

The "Anderson" is always locked with **three inches of water** It holds the steam perfectly and rarely requires attention.

Write for our instructive "Trap Book."

THE V. D. ANDERSON CO.
1935 W. 96th Street, CLEVELAND, OHIO.

MARTIN GRATES

Martin Anti-Friction Rocking Grates will burn slack coal and get the same steam results as ordinary grates do with best lump coal. Catalog tells why.

MARTIN GRATE COMPANY, 281 Dearborn Street, CHICAGO.

For Forced Draft

there's nothing equal to WING'S TURBINE BLOWER. Does away with tall, expensive stacks and *makes* cheap fuel burn with paying results. Catalog ?

L. J. WING MFG. CO., 90 West Street, NEW YORK

"SIROCCO"

TRADE MARK

FANS AND BLOWERS

BUILT ON THE TURBINE PRINCIPLE

SIROCCO ENGINEERING CO., 138 Cedar Street, New York

Over 7500 Hammel Oil Burners
In use under Stationary Boilers, Locomotives, Kilns, Etc.
Write for Circular of Hammel Patent Furnace for Water-Tube Boilers
HAMMEL OIL BURNER CO.
609 North Main Street, LOS ANGELES, CAL.

1--PRACTICAL
2--EFFICIENT
3--LOW-PRICED

The National Feed Water Heater is **practical** because it is designed on a plain and common-sense principle. It is **efficient** because it permits no contact of water with the shell and has no inside joints or straight tubes to leak. Heats the water to 210-212°. It is **low-priced,** costing less than *freak heaters,* which invariably cause trouble and expense. Nearly 3,000,000 H.P. in daily use. Catalog sent on request.

THE NATIONAL PIPE BENDING CO.
168 RIVER ST., NEW HAVEN, CONN.
120 Liberty St., New York. 54 High St., Boston, Mass.

Easily Taken Apart Without Tools

and without removal from the piping. This Dunham Trap is the most efficient and reliable trap made because it does not depend on floats, springs, buckets or other parts likely to get out of order. We'll send you one on free tri l.

C. A. DUNHAM COMPANY,
Marshalltown, Iowa.
Cleveland Chicago
Philadelphia Toronto

USE THE ADVANCE FEED WATER PURIFIER

It says "Stop!" to the scale-forming materials *before* they enter your boiler. It renders clear, clean feed water a reality. Circular No. 30 goes into details.

F. E. KEYES & SON, 20 Broad St., New York.

FLINN DIFFERENTIAL STEAM TRAPS

Save their Cost by Increasing Engine Efficiency.

THE EDWARD P. ALLIS COMPANY, Milwaukee, Wis.
[AFTER SELLING OVER 500 FLINN TRAPS.]

Replying to yours of the 17th inst., we would say that we have used the FLINN DIFFERENTIAL STEAM TRAP for a number of years, practically since its first introduction, and have found it the most general satisfactory trap we have ever used.

Yours, truly,
[Signed] THE EDWARD P. ALLIS COMPANY,
By Irving H. Reynolds.

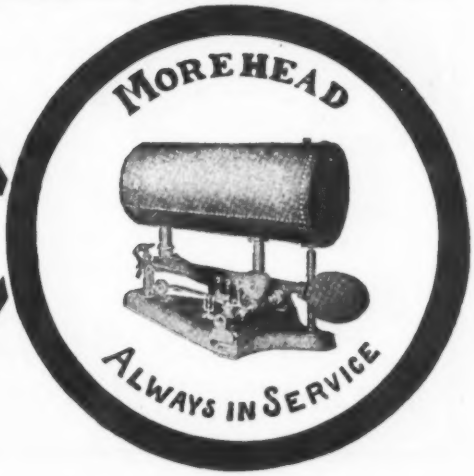
DESCRIPTIVE CIRCULAR ON REQUEST.

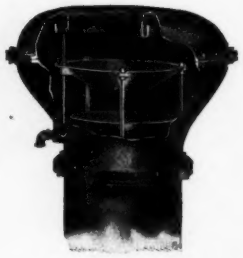
RICHARD J. FLINN, West Roxbury Station, Boston, Mass.

ITS OPERATION IS AS CERTAIN AS SUNRISE

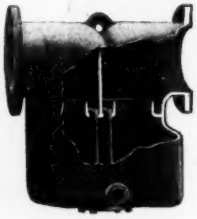
The Morehead Non-return Steam Trap has *got to work* as long as the force of gravity exists. When the water reaches a certain level, gravity exerts a greater power than the counterweights which support one end of the tank, and consequently the tap automatically tilts downward. Simple, isn't it? Catalog?

Morehead Manufacturing Co.,
1051 Grand River Ave., DETROIT, MICH.

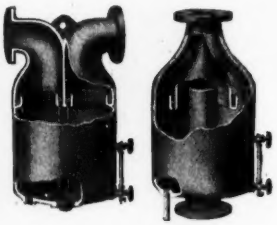




Exhaust Head

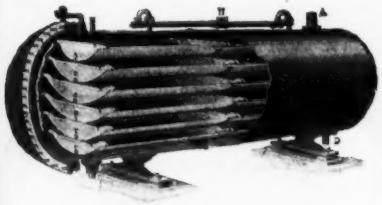


Oil Eliminator



Steam Separators

Feed-Water Heater—Class "R"



Live Steam Feed-Water Purifier

Look Down The Line

Then Write For Catalog Of

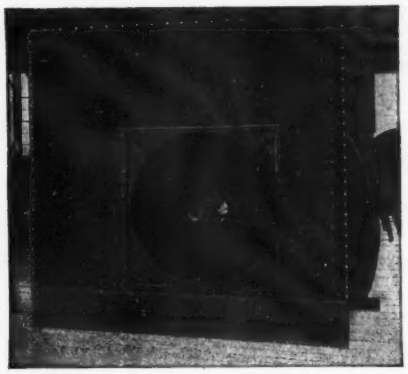
Hoppes Steam Specialties

Satisfaction Guaranteed

Sold On Their Merits

HOPPES MFG. CO.

19 Larch St. SPRINGFIELD, O.



Keep Warm and Happy with a Green Hot Blast Heater

Do not leave for November what you should do now. Write us to-day giving full particulars in regard to your Heating and Ventilating Problem or ask us to send our engineer, who can come to your plant and carefully study the work to be done. After ascertaining the cost of power for driving and average and maximum pressures and volumes required and after going over the proposed layout of flues and conduits, checking up calculations on temperature, humidity, etc., he will bring the data back to our engineering offices where your heating and ventilating system will be laid out on the most economical lines. Any system of heating is incomplete and imperfect that does not provide a proper supply ot air and, when it is appreciated that depleted air results in low mental and physical vitality, it will be seen that the thought and the time devoted to this problem will be well invested.

Any system of heating which does not provide for a proper supply of air is incomplete and imperfect. Every breath of air you take is practically exhausted tor breathing purposes when it is exhaled. The more continuous the exposure to bad air, as in schools, offices, and work shops, the more serious are its harmful effects.

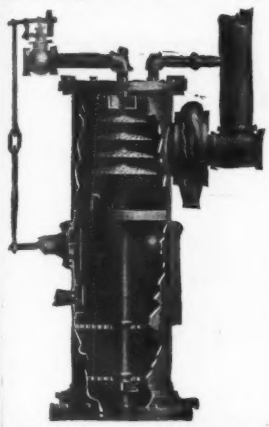
Write for our new Booklet "109P" on Heating and Ventilating, in which the requirements and methods of ventilating and heating are fully discussed.

The Green Fuel Economizer Co.

Matteawan, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

Engineers; Builders of Green's Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines. 133



OUR TWINS

EITHER ONE WILL SAVE 15% of fuel and preserve the boiler.

Write for Prices, Etc.

The Sims Co.,
ERIE, PA.

Branch Office:
136 Liberty St., New York,
Tel., 529 Cortlandt.

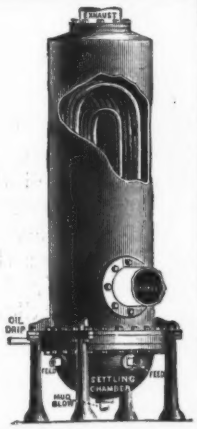
LOST

A large sum of money in plants where the exhaust steam is allowed to puff away to waste.

REWARD

to those who install the Patterson-Berryman Feed Water Heater, in the shape of lower fuel bills and less scale. 60 days in which to try it and buy it *or send it back.*

CATALOG!



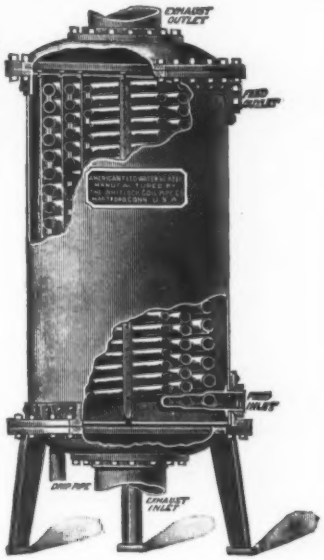
Frank L. Patterson & Co.,
26 Cortlandt St., New York, U. S. A.

The American Standard Copper Coil Feed-Water Heater

represents the highest type of feed-water heating apparatus and should always be used where the highest temperature and most satisfactory results are desired.

It costs no more than less efficient types.

It is the simplest and most widely used type of heater in the market today.



Manufactured by

The Whitlock Coil Pipe Company
Hartford, Conn.
New York Office, Singer Bldg., 85 Liberty St.

Scale Proof

The Reilly Multicoil

Heater cannot accumulate scale because the centrifugal force of the rapid flow scours the inside of the tube walls. Also, the continual trembling movement of the coils dislodges the first sign of film.

The Reilly Heater guarantees the highest and *longest maintained* efficiency. The shape of the tubes insures the thorough mixing of the water. Metal to metal screwed union joints between each tube and header. Any engineer can make repairs in a few minutes. *Write for our Heater Catalog.*

THE GRISCOM-SPENCER CO.,
90 West Street, New York.
Boilers—Engines—Tanks—Stacks—Plant Supplies

RETURN IT

at our expense if you are not perfectly satisfied that the Otis Tubular Feed Water Heater is one of the best paying propositions you ever put in your plant.

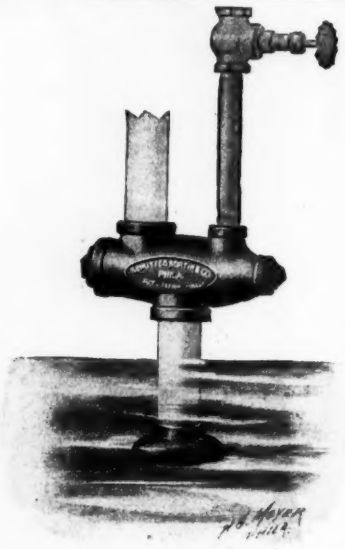
KEEP IT

long enough to thoroughly test the truth of the dozen guarantees we make regarding its efficiency. It will heat your feed water to 210-212°, prevent scale and separate the oil. Uses the *exhaust steam* only.

CATALOG ?

THE STEWART HEATER CO.
50 Norfolk Ave., Buffalo, N. Y.

KOERTING JET APPARATUS



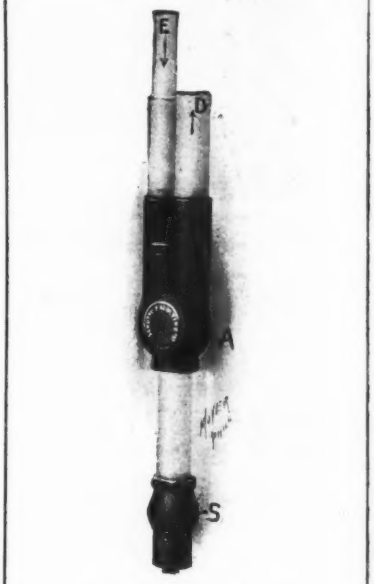
Water Jet Eductor

Water Jet Eductor:—These Eductors are chiefly used for draining cellars, pits, cesspools, etc., and find application on board ships, in boiler rooms, mines, etc. The motive power is pressure water. They are cheaper to work than piston pumps, have no moving parts, are noiseless in operation, simple and convenient to install.

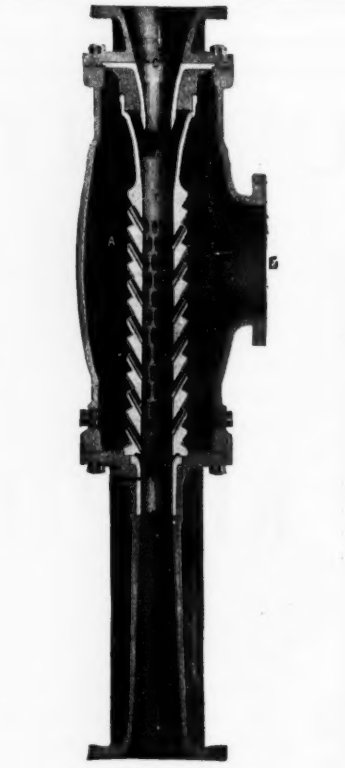
Write for Catalog 2-M

Artesian Well Syphon:—This machine is specially constructed for installation in wells of specified diameter; $3\frac{1}{2}$" to 10". It is operated by steam pressure and will elevate water to a height of $1\frac{1}{2}$ times the boiler steam pressure. Made for capacities from 700 to 14,000 gallons per hour. For prices and further particulars

Write for Catalog 2-A



Artesian Well Syphon



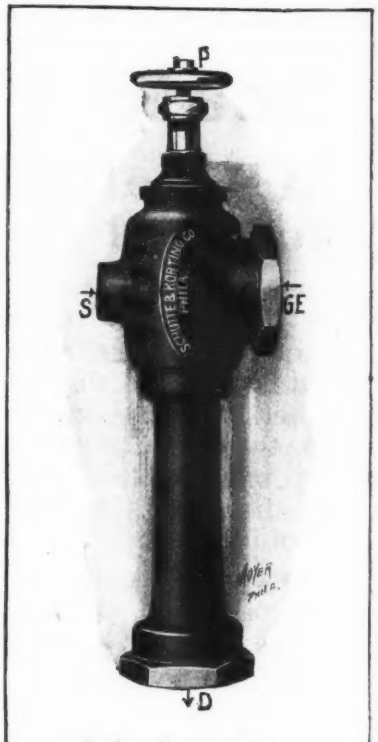
Eductor Condenser

Eductor Condenser:—This condenser can be applied to engines and turbines of any size, and will work with absolute certainty under all conditions of load variation. Air pumps are not required. There are no movable parts, therefore little wear and tear. Steady vacuum is maintained independent of load variation. Increased power 25%. Vacuum 93%. For details

Write for Catalog 5-A

Exhausters:—These Exhausters are used for creating a high vacuum and are constructed for operation either by steam or water pressure. They are used for agitating liquids, lifting liquids, pressing air or gases through liquids, priming pumps and other applications too numerous to here mention.

Write for Catalog 4-E



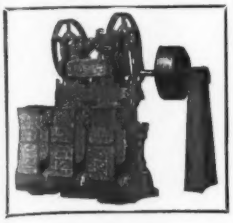
Steam Jet Exhauster

SCHUTTE & KOERTING CO., Tompson and 12th Sts. PHILADELPHIA, PA.

New York, 50 Church St. Boston, 98 High St. Chicago, 805 Security Building. Pittsburg, Keenan Building. San Francisco, O. C. Goeriz & Co.

Deming

Ask for Catalogue "G" and treatise "Feeding Boilers."



For any service. **Power**

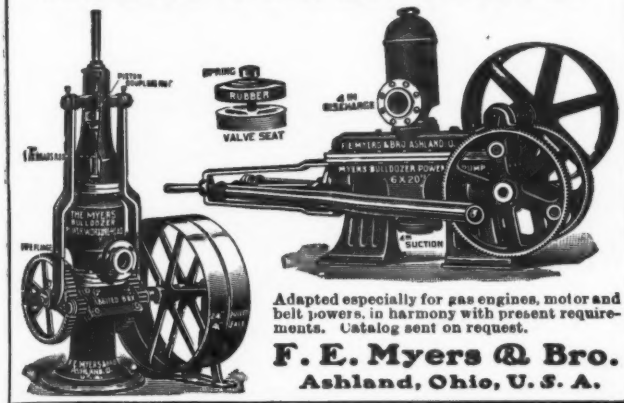
For operation by any power. **Pumps**

The Deming Company

Agencies in Principal Cities

Salem, Ohio

MYERS POWER PUMPS.

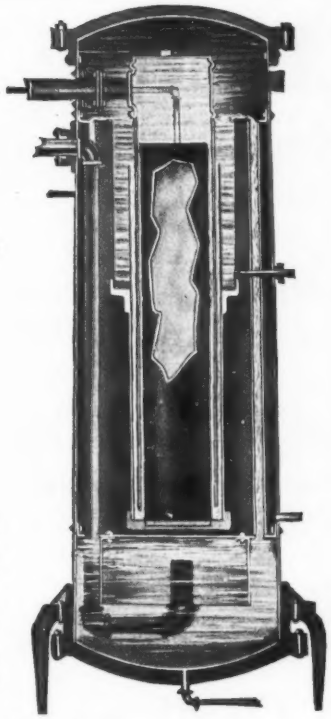


Adapted especially for gas engines, motor and belt powers, in harmony with present requirements. Catalog sent on request.

F. E. Myers & Bro.

Ashland, Ohio, U. S. A.

12% Saving On Fuel And A Greater Saving In Scale

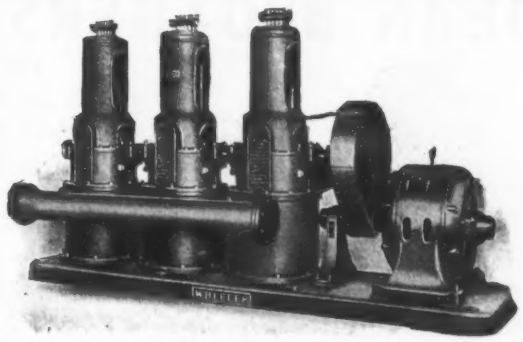


The Eclipse Purifier and Heater delivers feed water to the boiler at about 300° thus insuring freedom from scale with much greater safety and at much lower cost than is possible by any other method.

WRITE TODAY.

The Eclipse Feed Water Heater and Purifier Company,

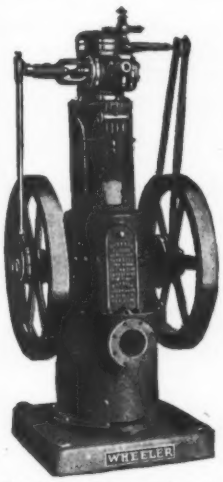
OSHKOSH, WISCONSIN.



Motor-driven Wheeler-Edwards Air Pump, Triplex Type.

Wheeler-Edwards Air Pumps for all Situations

No matter what the size of your installation, or whether you wish to have your air-pumps driven by steam, belt or electricity, or from the tail rod or cross head of your engine, we can supply you at once with drawings and dimensions of a suitable Wheeler-Edwards Air Pump and can build and ship the pump in a reasonable time, as we have a full line of patterns for all styles and sizes on hand.



Single Wheeler-Edwards Suction Valveless Air Pump.

The Wheeler-Edwards pump enables you to enjoy all the benefits of the highest vacuum obtainable by the use of separate condensation, and dry air pumps with air coolers, but at a considerable less first cost and less running expense.

When you consider that the Wheeler-Edwards pump has only one set of valves, and these easily accessible at all times, and that no valves are interposed between the pump chamber and the condenser you will understand how its ability to produce high vacuums can be combined with simplicity of construction.

WHEELER

CONDENSER & ENGINEERING CO.

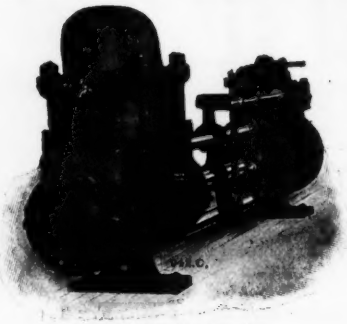
CARTERET, NEW JERSEY.

New York, Cincinnati, Chicago, Denver, Boston, Pittsburg, St. Louis, San Francisco, Atlanta, Houston, St. Paul.

(Builders of Wheeler Surface, Jet and Barometric Condensers, Wheeler-Volz Combined Surface Condensers and Feed Water Heater, Wheeler Feed Water Heaters, Barnard-Wheeler Cooling Towers, Wheeler-Edwards Air Pumps, Wheeler Centrifugal Pumps, Wheeler Rotative Dry Vacuum Pumps and Wheeler Multiple Effect and Evaporating Machinery). 6

DEAN BROTHERS STEAM PUMP WORKS

INDIANAPOLIS, IND.

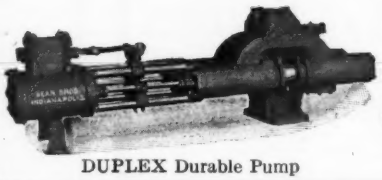


SIMPLE Boiler Feeder

JET AND SURFACE **CONDENSERS**

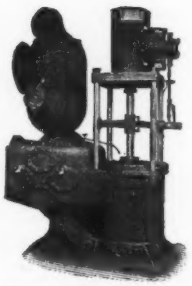
DUPLEX and SIMPLE Steam Pumps

Boiler Feeders
Fire Pumps
Electric Pumps
Vacuum Pumps
Deep Well Power Pumps



DUPLEX Durable Pump

Fly Wheel Pumps
Distillers' Pumps
Plunger Pumps
Ballast Pumps
Atlantic Type Pumps



Vertical Air Pump and Jet Condenser

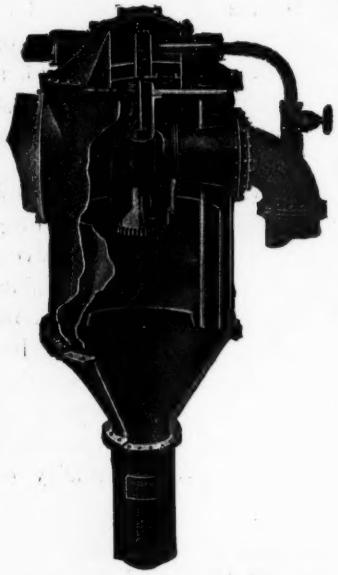
CATALOG FREE

We Make A Centrifugal Pump For Every Use

to which such pumps are adapted. We have been at it for nearly forty years. We make more kinds than any other maker, and we build them in the way that long experience and careful study have shown to be the best way. You know the advantages of Centrifugal Pumps in general; but there are other advantages which we believe are peculiar to our Pumps and we want you to know them.

MORRIS MACHINE WORKS,

New York Office, 39-41 Cortlandt St. BALDWINSVILLE, NEW YORK, U. S. A.



Alberger Barometric Condenser

ALBERGER

Complete Condensing Equipments

SURFACE High Efficiency

CENTRIFUGAL Internal Air Cooling

BAROMETRIC High Vacuum

DRY VACUUM PUMPS with Alberger Condensers give highest vacuum

COOLING TOWERS regulated and sub-divided air supply. Perfect water distribution.

WAINWRIGHT HEATERS

Even flow Feed Water Heaters. Distilling Condensers. Hot Water Service Heaters.

High Water Velocity through Straight Corrugated Copper Tubes. Large Capacity. Small Size.

CORRUGATED COPPER EXPANSION JOINTS.

Wainwright Feed Water Heater

ALBERGER CONDENSER COMPANY,

95 LIBERTY ST., NEW YORK, N. Y.

Reeves & Skinner Machinery Company.
617 Chemical Bldg., St. Louis, Mo.

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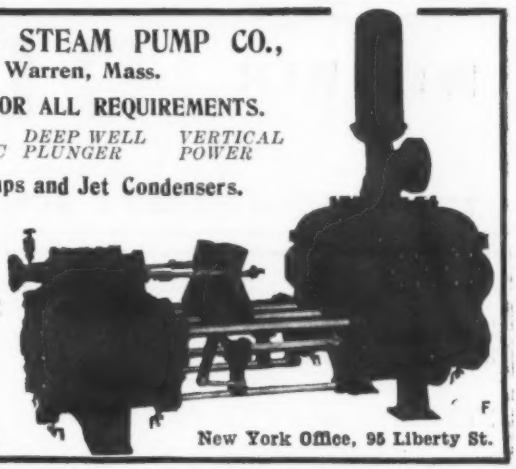
Warren, Mass.

PUMPS FOR ALL REQUIREMENTS.

PISTON HYDRAULIC DEEP WELL PLUNGER VERTICAL POWER

Air Pumps and Jet Condensers.

Combined Air and Circulating and Marine.



CATALOG ? F

New York Office, 95 Liberty St.

ON ACCOUNT

of their extremely low cost of operation and the small amount of attention required

Goulds Efficient Power Pumps

are growing in favor wherever they are installed. Let us send you Catalog of Pumps for every service.

The Goulds Mfg. Co

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New York. Philadelphia. Pittsburg. St. Louis. New Orleans. Chicago. Los Angeles. San Francisco Louisville, Ky.

Prescott Condensing Apparatus

Complete Line for Power Plants.

Boiler Feeds and General Service Pumps for all conditions.

Send for Catalog 20-H.

FRED M. PRESCOTT STEAM PUMP CO.

Milwaukee, Wis.

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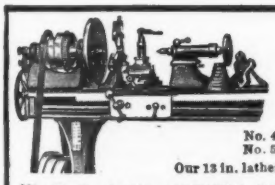

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LATHES

W.F. AND J.C.

9 in. to 13 in. Swing.

No. 4½ Lathe, 9 in. x 25 in., List $ 75.00
No. 5 Lathe, 11 in. x 34 in., List 100 00

Our 13 in. lathes made 5 to 10 feet long. Send for lathe catalog.

W. F. & JOHN BARNES CO., 990 Ruby Street, Rockford, Ill.

NO AIR PUMP NEEDED

with the **Baragwanath Syphon Condenser.** That's one reason why this condenser is free from the usual condenser troubles.

If you are interested in reducing your fuel bills 20 to 35% and increasing your engine power a like amount, write for full particulars.

A Vacuum is better than an Air Pump.

WM. BARAGWANATH & SON,

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STEAM PUMPS

QUALITY AND PRICES ARE RIGHT.

BLAKE PUMP & CONDENSER CO.,

FITCHBURG, MASS.

☞ YOUR LOSS IF YOU DON'T KNOW US.

Guaranteed to form the best Vacuum by head of water or by supply pump

The Bulkley Injector Condenser

In general use on all classes of engines.

New York Office: 141 Broadway.

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COOLING TOWERS

Fan—and Natural Draft

GEORGE J. STOCKER

St. Louis, Mo.

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MORRIN CLIMAX BOILERS

Are free from all weaknesses, make steam fast, holds the pressure under all conditions, and gets FULL VALUE out of every scrap of coal and drop of water.

THE MORRIN CLIMAX BOILER CO., - - - BROOKLYN, N. Y., U. S. A.

Sterling Ventilators

not only guarantee pure air, but they add to the appearance of your buildings in the bargain Good air—good work. Write for details.

No More Oily Drizzle

if you use a Sterling Exhaust Head. The "Sterling" guarantees dry steam and keeps your roofs and sidewalks in good condition. Catalog ?

STERLING BLOWER AND PIPE MFG. COMPANY, 6827 First Avenue, Hartford, Conn.

NEW YORK OFFICE, 109 LIBERTY STREET.

THE BABCOCK & WILCOX COMPANY

85 LIBERTY STREET, NEW YORK

WATER TUBE STEAM BOILERS

STEAM SUPERHEATERS—MECHANICAL STOKERS

Barberton, Ohio — WORKS — Bayonne, N. J.

BRANCH OFFICES

Boston—Delta Building
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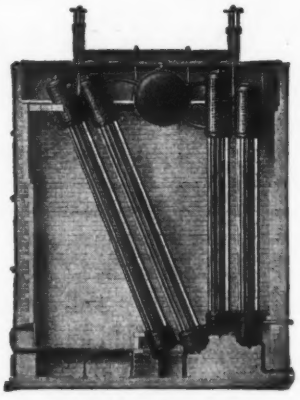
The Bigelow-Hornsby Water Tube Boiler

UNLIMITED SIZE OF UNITS, 2,500 HORSE POWER OR MORE.
COLDEST WATER MEETS THE COLDEST GASES.
DIRECT HEATING SURFACE ABOUT FOUR TIMES AS GREAT AS THE AVERAGE WATER TUBE BOILER.
ALL PARTS, BOTH EXTERNAL AND INTERNAL, READILY ACCESSIBLE.
ALL BOILER TUBES PERFECTLY STRAIGHT.

Large well Illustrated Catalog on request.

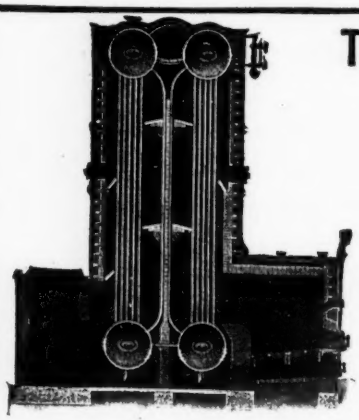


ALL TYPES OF FIRE TUBE BOILERS.

Vulcanizers, dryers, foundry cupolas, tanks, stacks and special work.

THE BIGELOW COMPANY, NEW HAVEN, CONN.

New York Office, 85 Liberty St. Boston Office, 141 Milk St.



Type B

THE RUST WATER TUBE BOILER

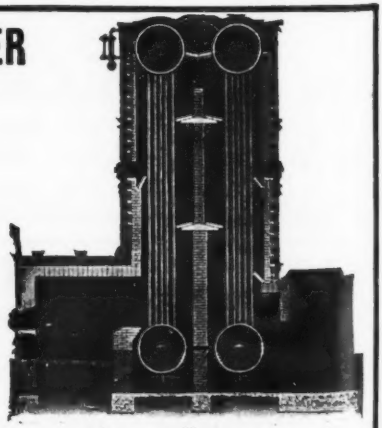
Safe
Simple
Economical
Durable
Accessible

THE RUST BOILER COMPANY,

Pittsburgh, Pa.

BRANCH OFFICES
New York, 50 Church Street.
Birmingham, Ala., First National Bank Building.

Write for Report of Tests by William Kent.



Type C

HEINE WATER TUBE BOILERS

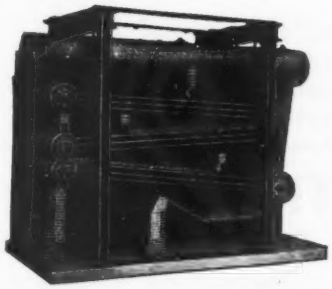
AND SUPERHEATERS

All Flange Steel Construction

Send for { Boiler Logic and Superheater Logic

Heine Safety Boiler Co. 421 Olive St., St. Louis, Mo

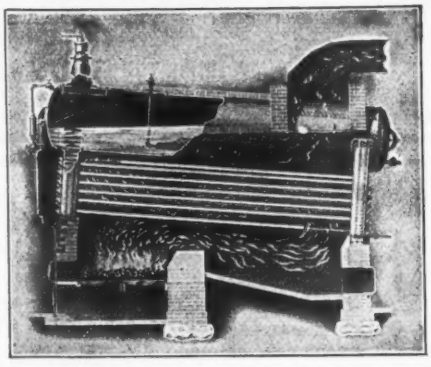
SET IN A STEEL FRAME



Thus the Vogt Water Tube Boiler eliminates much trouble due to the ordinary brick settings. Steel construction throughout—not a pound of cast iron used. Rapid circulation and large heating surface. Write for circular.

Henry Vogt Machine Co., Inc.,
Louisville, Ky.

FRANKLIN WATER TUBE BOILER



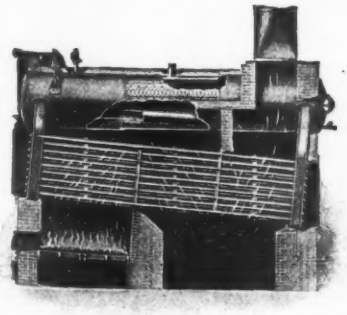
BUILT BY

FRANKLIN BOILER WORKS CO.,

TROY, N. Y.

SALES OFFICE
39 Cortlandt St.,
New York, N. Y.

Water Tube Boilers



All Wrought Steel Construction

Ask for New Catalog P. W.

ESTABLISHED 1865.

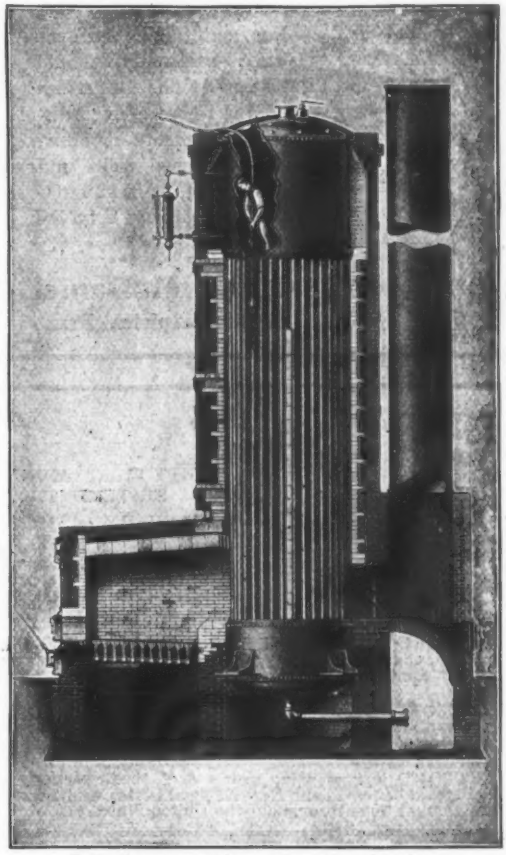
E. KEELER CO.
Williamsport, Pa.

New York, Philadelphia, Chicago, San Francisco, Wilkesbarre and New Orleans.

The Wickes Boiler

Vertical Water Tube

Ever cleaned a boiler? Know how hard it is? If you have you will appreciate this boiler at a glance.



Cut shows position of man cleaning; Is it laborious compared with usual forms?

Two 12″ x 16″ manholes open the Wickes Vertical Water Tube Safety Steam Boiler from top to bottom for inspection and cleaning. Every tube can be looked through; every tube washed or scraped.

Safe.
Low cost of maintenance.
High furnace and heat abstracting efficiency.
Absolutely dry steam.

Ask us for Bulletins—sent free.

The Wickes Boiler Co.

Main Office and Works:
Saginaw, Michigan

Sales Offices:
1411 West Street B'ld'g, West and Cedar Sts., New York City,
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Penobscot B'ld'g, Detroit, Mich. Empire Bl'd'g, Pittsburg, Pa.
601 Brown-Marx B'ld'g, Birmingham, Ala.

Parker Boiler Company,
Pennsylvania Building, Philadelphia, Pa.

PARKER BOILERS

NEW YORK—
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PITTSBURG—
1806 Machesney Bldg.
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DENVER—
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SAN FRANCISCO—
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Watson Steam Pump Governor

For maintaining an even water pressure. Should be used on all steam pumps where a fixed discharge pressure is desired. Designed right and made right, it is automatic and reliable. Send for catalogue.

Watson & McDaniel Co.,
Philadelphia, Pa.

PREVENT EXPLOSIONS

by preserving a perfect water level with a Murray Automatic Boiler Feed Regulator. You will also save enormous quantities of fuel, protect your engine from condensation and run your plant with less help.

Particulars on request.

Murray Automatic Boiler Feed Co.,
Detroit, Michigan.

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO. HARTFORD, CONN.

1866 1908

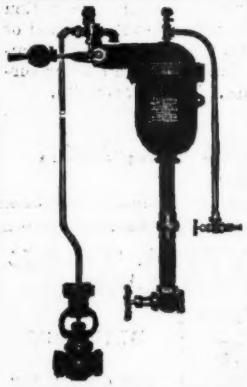
FORTY-FIRST ANNUAL STATEMENT.
JANUARY 1st, 1908.

Capital	$1,000,000.00
Surplus	1,006,868.06
Reserves	2,053,326.74
Assets	4,060,194.80

The HARTFORD was the PIONEER Company in the field of steam boiler insurance and it is the only company which makes a specialty of and does exclusively a steam boiler inspection and insurance business.

The HARTFORD is the only Company whose entire talent and energy are applied to the study of steam, to the scientific construction and installation of boilers and to their periodical inspection by expert mechanics.

The HARTFORD is now doing nearly ⅛ of the inspection and insurance of steam boilers in the New England States, and nearly ⅓ of the entire amount done throughout the United States.



The Vigilant Feed-Water Regulator

for steam boilers was the first in the *field*, and has the longest and best record of any of these devices.

Costs Less to Operate and Maintain

Constructed on a different and better principle than any other.
Investigate it and the

FULTON PUMP GOVERNOR

and send for latest catalogue with list of users.
A guarantee from a responsible firm with every machine.

THE CHAPLIN-FULTON MFG. CO.
Pittsburg, Pa.

J. S. Ward, Agt., 7-9 S. Jefferson St. Chicago.

KEWANEE TANKS

We are the largest and best manufacturers of storage and pressure tanks in the United States. The story is told. See Book No. 51. Send your specifications.

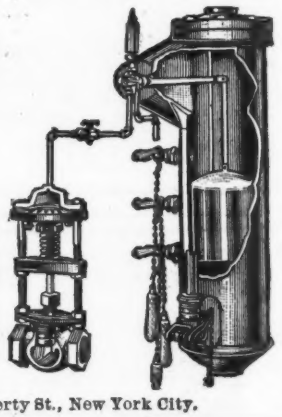
KEWANEE BOILER COMPANY
KEWANEE, ILLINOIS.

THE
BERRY
Safety
Automatic
Feed Water REGULATOR

Send for Catalogue

BERRY ENGINEERING COMPANY
Chester, Penn.

Metropolitan Office, 136 Liberty St., New York City.



TUBULAR AND WATER TUBE TYPES

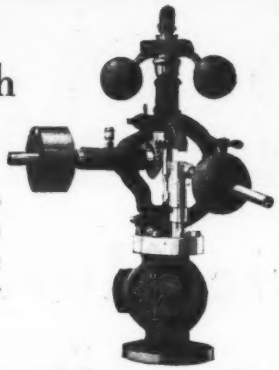
TUDOR BOILERS

INCORPORATED 1834

The Tudor Boiler Mfg. Co., Cincinnati, O.

TANKS AND STEEL PLATE WORK

A Little Higher Price For A Much Better Governor



The Gardner Governor is fitted with an automatic stop which closes the valve the instant a belt breaks or other accident occurs. *Write.*

The Gardner Governor and Separator Co.
Quincy, Illinois.

More in Use Than all Others Combined

If you ask any better proof of Fisher Governor efficiency we will send a governor to prove its ability in your plant. Any pressure to 8000 lbs. per square inch. Write.

Fisher Governor Company
Marshalltown, Iowa

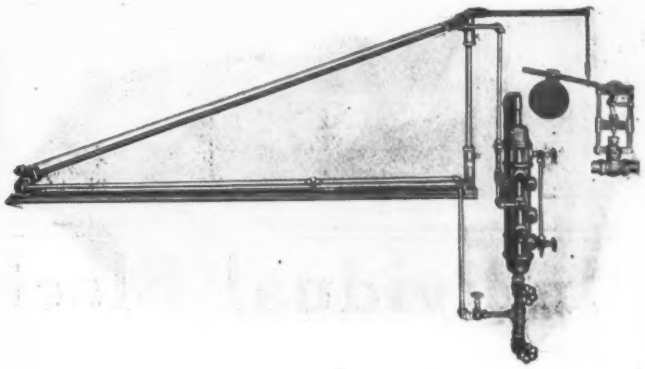
Here is Another Curtis Specialty

The Curtis Damper Regulator

is the most simple, durable and economical device on the market. Regulates to any position with the varying steam pressure—no water connection. It is fully up to the standard of other Curtis products.

IF YOU ARE NOT FAMILIAR WITH THEM WRITE FOR DESCRIPTIVE CATALOG.

Julian D'Este Company
24 Canal St., Boston, Mass.



Feed Water Regulator Reliability.

How To Get It?

1. *Eliminate parts subject to wear and deterioration.*
2. *Diminish the number and complication of parts.*
3. *Place all parts where they can be inspected and tested readily.*

This means that you shall not have pilot valves nor other small delicate parts through which steam or water is wire-drawn at boiler pressure, that you shall avoid stuffing boxes, subject to high steam pressure, that you shall discard floats, because they water-log and scale up, and diaphragms because they blow out, that you shall avoid springs because their life and action are uncertain, that you shall avoid internal levers and joints since they become clogged, that you shall have as few working parts as possible, and that these parts shall always be in sight.

The Copes Feed Water Regulator meets all these requirements. There are no floats, springs nor diaphragms, and the only working parts are plain levers located in plain sight, where they indicate by their position what they are doing and where they can be readily operated by hand.

Neither scale, grease, impure water nor age affect the working of the Copes Regulator. In fact, we guarantee each Regulator for FIVE YEARS and would be pleased to refer you to plants where it has been in satisfactory service for ten years.

Send for our new book "P."

American Boiler Economy Co.
North American Building
PHILADELPHIA, PA.

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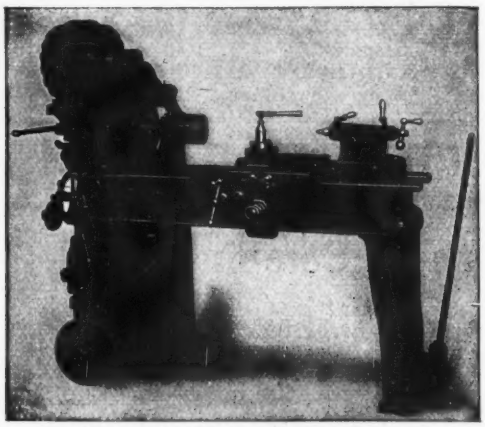
Westinghouse

Individual Electric-Motor Drive

Adding to your equipment

is easy with individual motor-driven machinery, simply a matter of floor space. No line shaft nor belting to bother with, just a wire. You can run a wire anywhere.



Portable Lathe Driven by Westinghouse Motor.
Manufactured by Williams & Wilson, Montreal, Can.

Westinghouse Electric & Mfg. Co.

Atlanta, Baltimore, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Kansas City, Los Angeles, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, St. Louis, Salt Lake City, San Francisco, Seattle, Syracuse

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Foster Superheaters

Increase capacity of boilers, give more power with less fuel, and prevent all loss and trouble due to wet steam.

POWER SPECIALTY CO.,
111 BROADWAY, NEW YORK.

MOUND TOOLS. FOR THE ENGINE ROOM.

This cut represents our new set of 20 tools often used for use in the engine room. Strictly high-grade tools with all the good points of toolsmithing in their make-up. Conveniently arranged in finished Oak Case and every tool is guaranteed.

No. 20 Set of 20 Tools . . . $4.00.

Book "Engineers' Chums" free. Address Dept. B

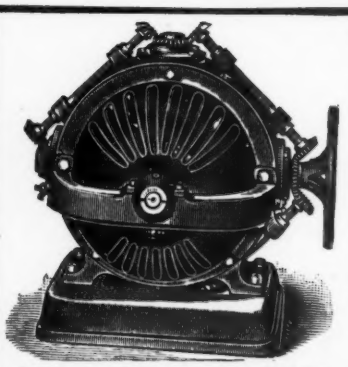
MOUND TOOL AND SCRAPER CO.
1606-1608 N. BROADWAY, ST. LOUIS, U. S. A.

Reinforce The Tube Ends

With Cruise Boiler Tube Protectors

and your old tubes will last twice as long as they otherwise would. The protectors cost but a trifle and are easily secured in place. WRITE.

CRUISE & COMPANY,
144-150 Broadway, ELIZABETH, N. J.
Telephone Nos. 745R—526R.



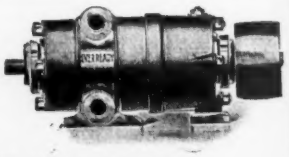
TURN THE WHEEL

That's all you have to do to obtain a wide range of speeds with a Stow Multi-Speed Motor.

The Stow is the only motor which is absolutely complete in itself. It saves your power for you. Let us mail you a Stow Catalog to stow away and hold for reference.

STOW MFG. COMPANY, Binghamton, N. Y.
GENERAL EUROPEAN AGENTS
Selig, Sonnenthal & Co., 85 Queen Victoria Street, London, England.

We Manufacture
AN ECONOMICAL AND DURABLE ROTARY ENGINE
Send for Catalogue.



Ball-Cooley Engineering Co.
316 HUDSON ST., NEW YORK CITY and 159 GREEN ST., BOSTON.

ALBERGER TANDEM GAS ENGINES

ACCURATE REGULATION FOR ELECTRIC SERVICE—AUTOMATIC CUT-OFF AND RITES FLY-WHEEL GOVERNOR

A.H.ALBERGER COMPANY

45 TO 600 H.P. USING NATURAL GAS
85 TO 500 H.P. USING PRODUCER GAS

695-697 ELLICOTT SQ.
BUFFALO, N.Y.

VERTICAL STYLE C & C MOTOR

Well adapted for Driving Pumps, Ventilating Fans in Shafts or Flues, Large Drill Presses, etc. The compactness of **C & C Motors** is due to the use of Steel Magnets of the highest grade, and perfect armature ventilation.

The C & C Electric Co.

General Office and Works, GARWOOD, N. J.

New York, 149 Broadway. Boston, H. A. Howard, 115 Purchase St. Philadelphia, West End Trust Bldg. Agencies in all principal cities.

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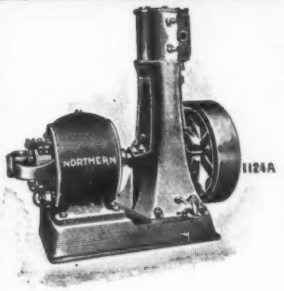


Northern Generator direct connected to American Blower Co. "A" Engine.

Private Electric Plants For Office Buildings, Club Buildings, Hotels, Country Residences, Etc.

Give the best, most economical and reliable service when Northern Generators are used. Our product is charactized by its high efficiency, sparkless commutation, close regulation, cool running, simplicity, compactness and strength.

Send for Leaflet No. 33146.

NORTHERN ELECTRICAL MFG. CO.,

Standard and Special Electrical Machinery
Direct Current—Alternating Current

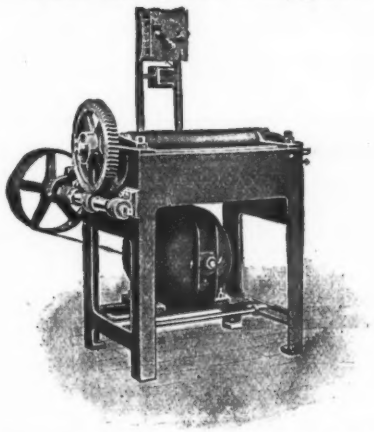
MADISON, WISCONSIN.

TRIUMPH

MOTORS

For Service

Let us send you our booklet "The Way to Forget"



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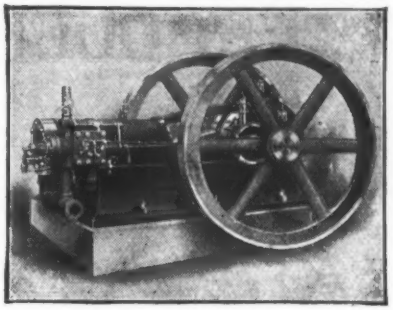

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DU BOIS GAS ENGINES

Du Bois Engines are cool running, easily governed and are designed to operate on Natural or City Gas, Gasoline and Producer Gas. For all general power purposes they prove the most economical Sizes 5 to 375 h. p.

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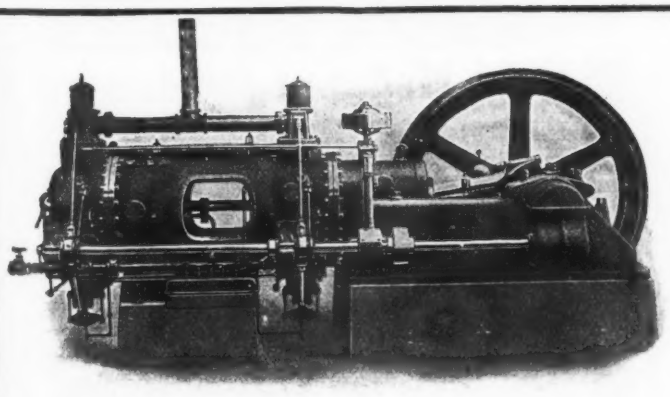
ESTABLISHED 1877.

805 BRADY STREET, DU BOIS, PENNA.



WARREN GAS ENGINES

Horizontal and Vertical Types up to 700 H. P.

NOT AN EXPERIMENT

Economy and Reliability Have Been Demonstrated by Actual Service

FULLY GUARANTEED

For All Street Railway, Electric Light and Power Requirements

STRUTHERS-WELLS COMPANY,

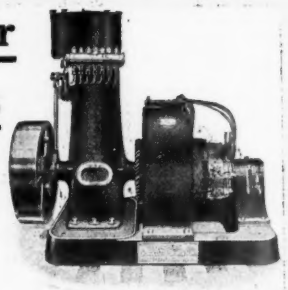
WARREN, PENNA.

New York Office, 26 Cortlandt Street. **Pittsburg Office, 310 House Building.**

One Reservoir Oils All Parts

thus saving the engineer's time and insuring proper lubrication at all times.

These generating sets are compact, reliable, economical and will outlast any similar machine on the market. Write.



Engberg's Electric and Mechanical Works,
St. Joseph, Mich.

The Loomis-Pettibone System

generates the right gas for gas engines and delivers 80% of the heat units contained in the fuel used. The gas is free from tar. Here is real

Economy and Efficiency

Write for Catalogue "Type C"

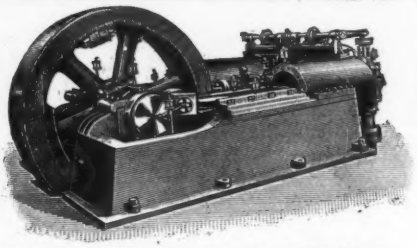
Power & Mining Machinery Co.
New York Office, 115 Broadway — Home Office, Milwaukee, Wis.

GAS PRODUCERS
FOR
POWER AND FUEL GAS;
COAL GAS & WATER GAS APPARATUS.

THE GAS MACHINERY CO.,
CLEVELAND, OHIO.

208

The Miller Gas Engine



is the result of ten years of practical experience in the design of gas engines for heavy duty. It is built in 35, 50, 75, 100, 150 and 250 H.P sizes. Among its unusual features is our patented system of vacuum governing, which gives a regulation only equaled by the steam engines. The many other good points of this most economical source of power are fully described in the catalog, which is sent on request.

THE MILLER IMPROVED GAS ENGINE CO.,
Springfield, Ohio, U. S. A.

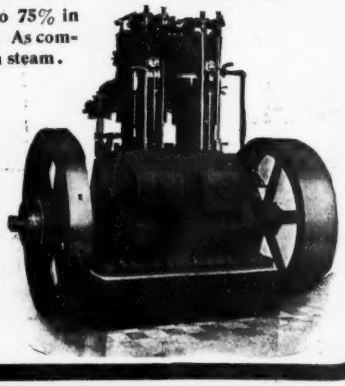
FOOS PRODUCER GAS ENGINES

Save 50 to 75% in fuel costs. As compared with steam.

Foos Engines, owing to their efficiency and reliability, are the ideal power for factories, water works, electric plants, etc. They pay for themselves in one to three years.

COMPLETE ELECTRIC AND PUMPING PLANTS.

Get Catalogue K.



THE FOOS GAS ENGINE CO.,
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OVERCOME YOUR ALIGNMENT TROUBLES!

USE B-M-A FLEXIBLE LINK COUPLING

The ideal method for connecting prime movers to

GENERATORS, BLOWERS, COMPRESSORS, PUMPS, ETC.

Standard sizes up to 500 H.P., but we design them to meet all conditions and will be pleased to learn of yours.

THE BRUCE-MERIAM-ABBOTT CO.,
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PRODUCER GAS

THE CHEAPEST POWER IN THE WORLD

GAS ENGINES, GAS PRODUCERS
COMPLETE PLANTS INSTALLED

BROOMELL, SCHMIDT & STEACY CO.,
YORK, PENNSYLVANIA.

OTTO ENGINES

Gold Medal at Jamestown

OTTO

The U. S. GOVERNMENT paid this Company a big compliment when it selected the "OTTO" Engine for use in making fuel tests at the Jamestown Exposition.

The Jury of Awards also proved its fitness for its task when it *awarded* the "*OTTO*" the *GOLD MEDAL.*

The "OTTO" has won *FIRST PRIZE* at every large Exposition held in this Country since the Centennial in '76.

OTTO OTTO

The Otto Gas Engine Works,
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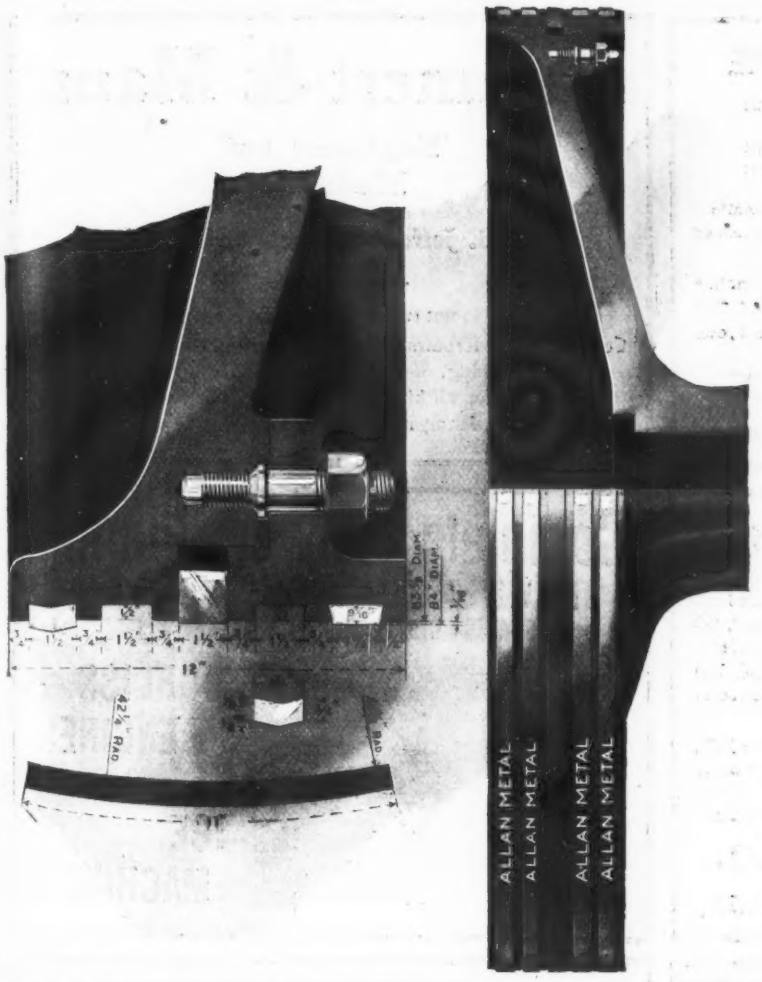
STANDARD OF THE WORLD



Allan Metal Faced H. & L. Pressure Pistons

produce and maintain a highly polished cylinder. They reduce friction, which is loss of power, to a minimum. They prevent excessive wear and cannot under the most trying conditions score the cylinder. Allan Metal affords space between the rings for better distribution of cylinder lubrication. Seventeen years of service in thousands of engines has proven the worth of Allan Metal. Our bulletins are of mechanical interest to every superintendent and chief engineer. Let's place your name on our mailing list?

A. Allan & Son,

Inventors and Sole Manufacturers

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One 50 H. P. Tandem Cylinder Gas Engine little used, at a bargain. Also 3 or 4—25, and 30 H. P. Gas Engines at a reduced price. Good as new.

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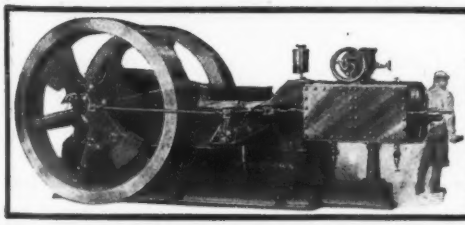

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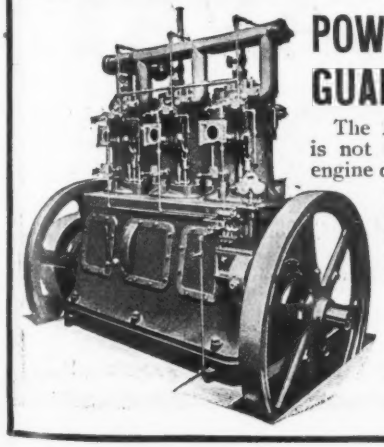

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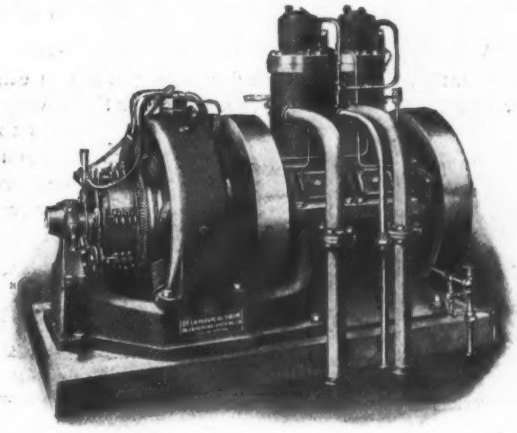

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are cheaper, simpler, more compact than any other motive power. 8 H. P. hours per gallon of cheap oil.

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The "De La Vergne" Vertical two-Cycle 4 to 25 H. P.
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One 14-ft. diameter by 28-inch face pulley, turned for belt. Hub bored 11 inches diameter. Wheel weighs 15,000 pounds.

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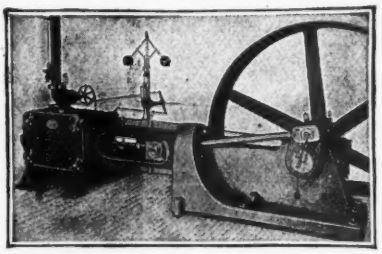

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DON'T SHUT DOWN

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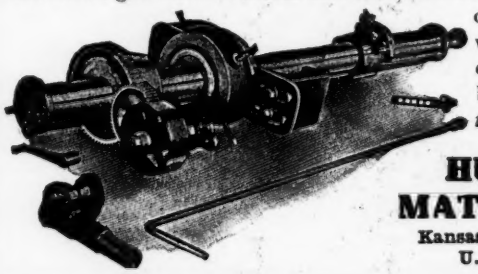

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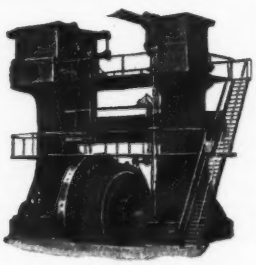

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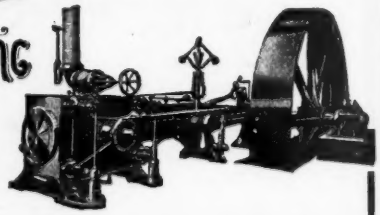
BUILT BY THE FISHKILL LANDING MACHINE CO., FISHKILL ON HUDSON, N.Y.



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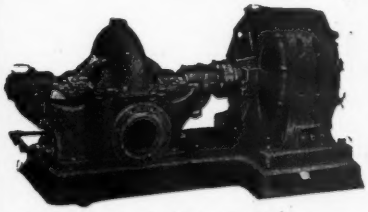

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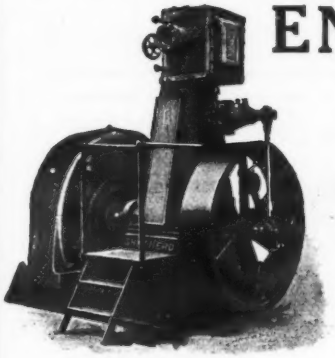

of any size or type are always **good engines.** No expense or effort is spared on our part to make them such, and our solid, steadily increasing business proves that buyers appreciate this fact. We offer unusual superiority in

Small Vertical Engines

ranging from 8 to 75 H. P. These are the only small steam engines made whose efficiency is comparable with that of larger sizes.

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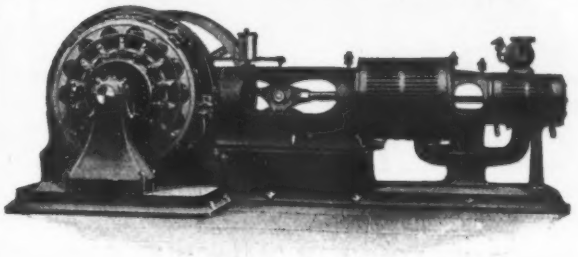
THEY GET ALONG WELL TOGETHER



If your Dynamo is not made for your Engine, or vice versa, there's likely to be trouble. But if each is made to run with the other, such as Ridgway Dynamos and Engines, then perfect harmony is bound to result between them.

You'll appreciate this unison even more, if your plant is "Over the hills and far away," where a breakdown is a real serious matter and repairs hard to 'tend to.

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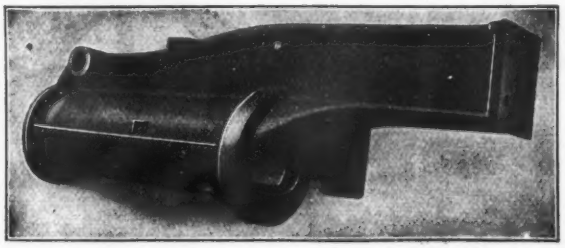

ONE ROLLINS ENGINE FEATURE

which does its share toward making the "Rollins," *the most successful heavy duty engine* is the heavy web on back and broad support under center of frame.

The "Rollins" is strong where other engines are weak, and the above illustration pictures what makes the "Rollins" better able to resist varying strains than ordinary engines. Write for catalog and *know the* "Rollins" thoroughly in every part.

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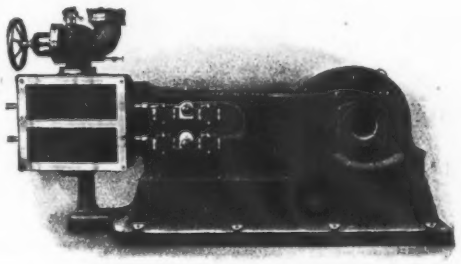

We can make quick delivery on the following engines subject to first order:

1—16	x16	Center	Crank	Belted,	180 to 200 H. P.
1—13½	x13	"	"	"	110 " 125 "
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All are new and have never left the shop.

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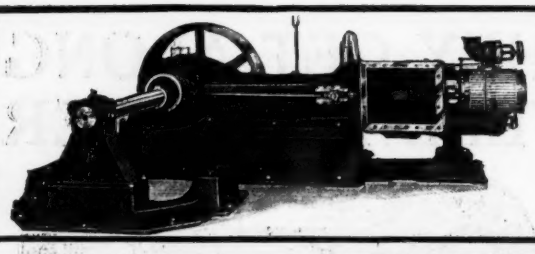

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have set a new mark for maintained economy, close regulation and perfection of lubrication.

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Simple, condensing and compound, 50 H. P. to 2000 H. P. Complete steam power outfits for every service, Superior in workmanship and performance.

THE BASS FOUNDRY & MACHINE COMPANY,
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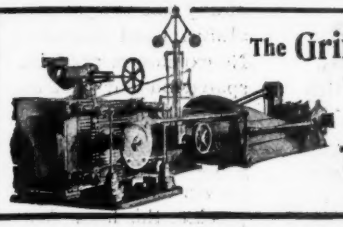

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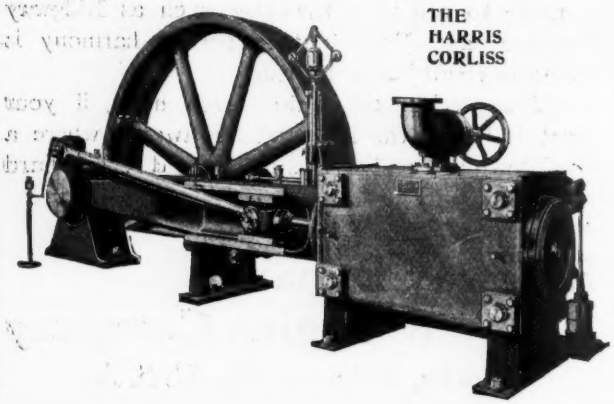
Manufacturers of
The Ohio Corliss Engine and Hoisting Engines



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The Porter Type Governor

is fitted with an automatic stop-motion the office of which is to cut off the supply of steam from the cylinder in case of slipping or breaking of the governor belt.

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Close Regulation of Speed
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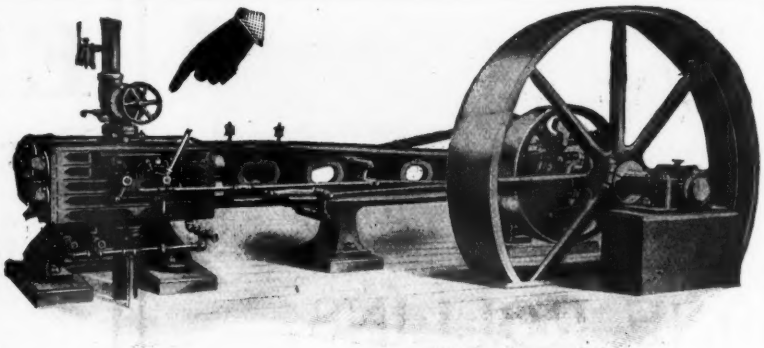

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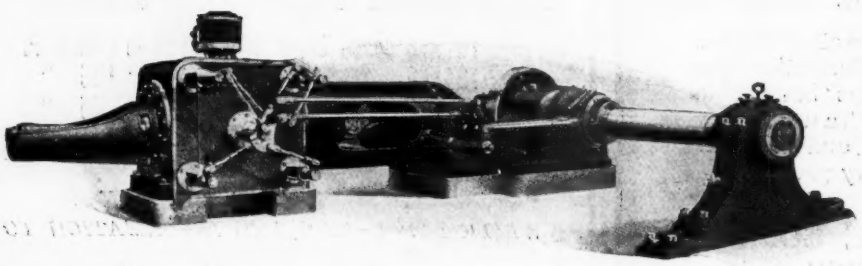
THE CLARK HEAVY DUTY CORLISS ENGINE



Valve travel never varies. No other Corliss engine has this advantage. Result perfect valve seats. Cuts off at all loads. As quick as the releasing gear. Heavy duty bed with bored guide. Main bearings half diameter of pistons. Length in proportion. Outboard bearing pedestal type. Adjustable in all directions. And self-oiling. Shaft swelled between bearings. Wheels above ten feet in diameter in halves. All wheels have split hubs. Our engines are unequaled for low steam consumption, perfect regulation, long life, nominal repairs, beauty of design. Perfect distribution of metal, high class material. Perfect workmanship

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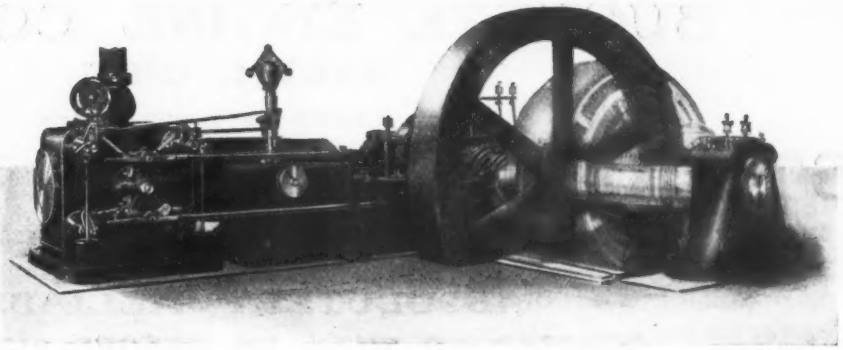

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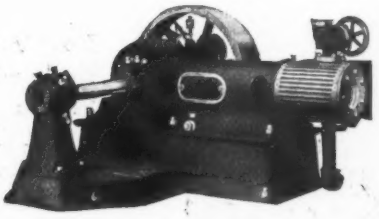
is largely due to the fact that the frame is bored out by an accurate boring mill, the bearings for the



pillow blocks are spotted and the frame end is faced to receive the cylinder all at one setting. *Catalog?*

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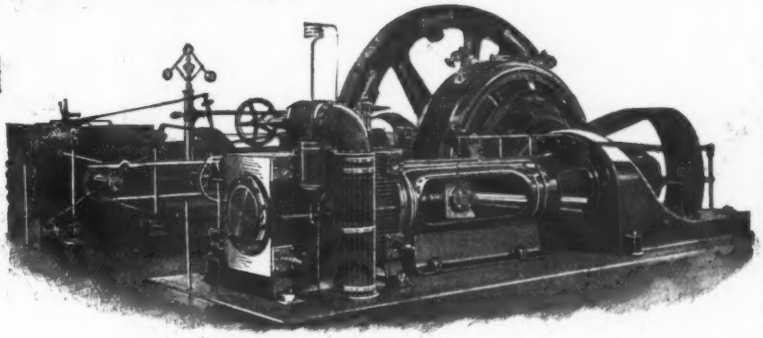

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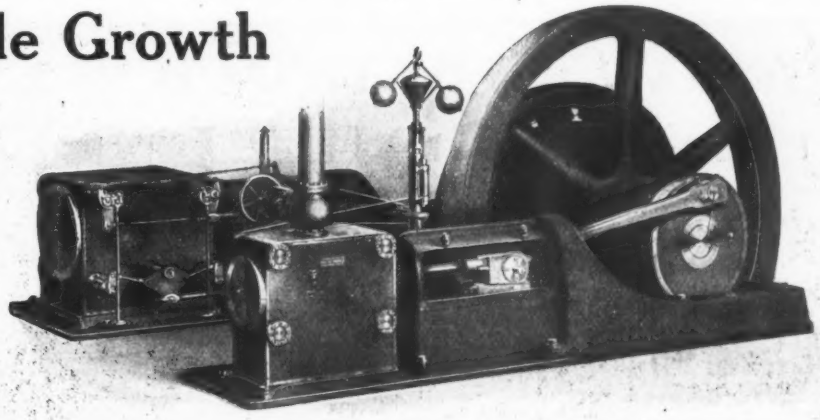

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HIGH IN DUTY, SUPERIOR IN REGULATION

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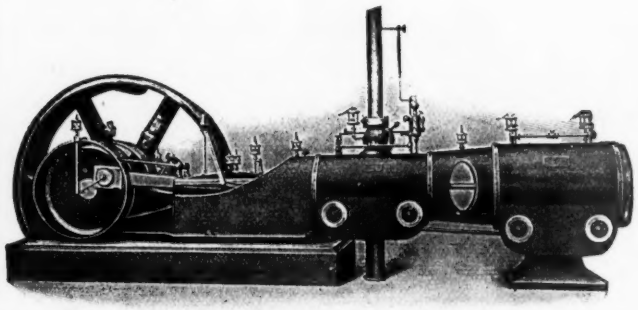

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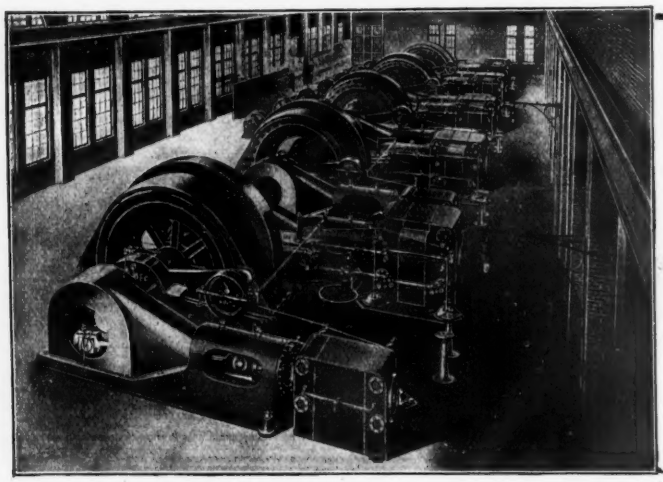

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The maximum capacity of the plant shown is 12000 H.P.

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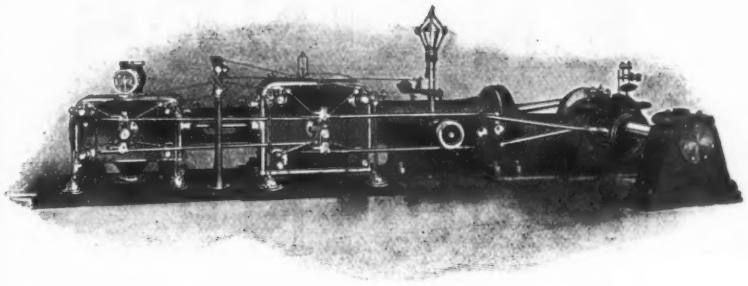

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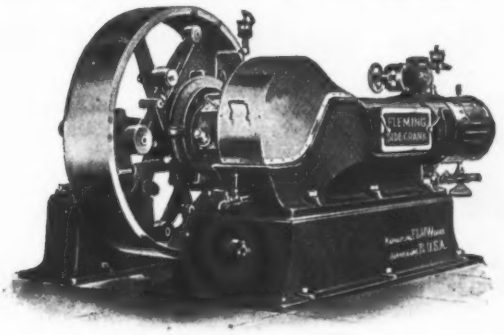

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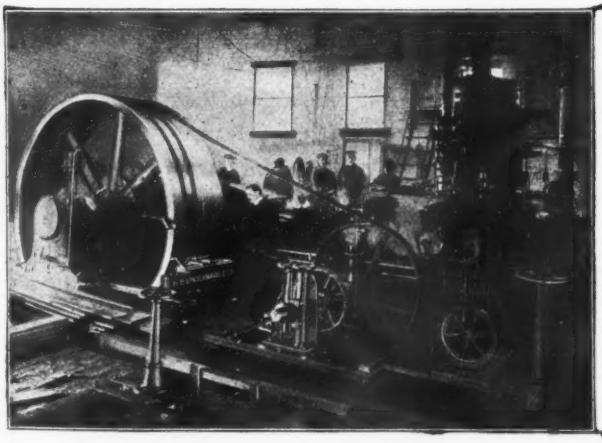

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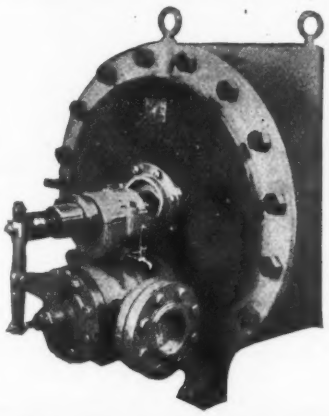

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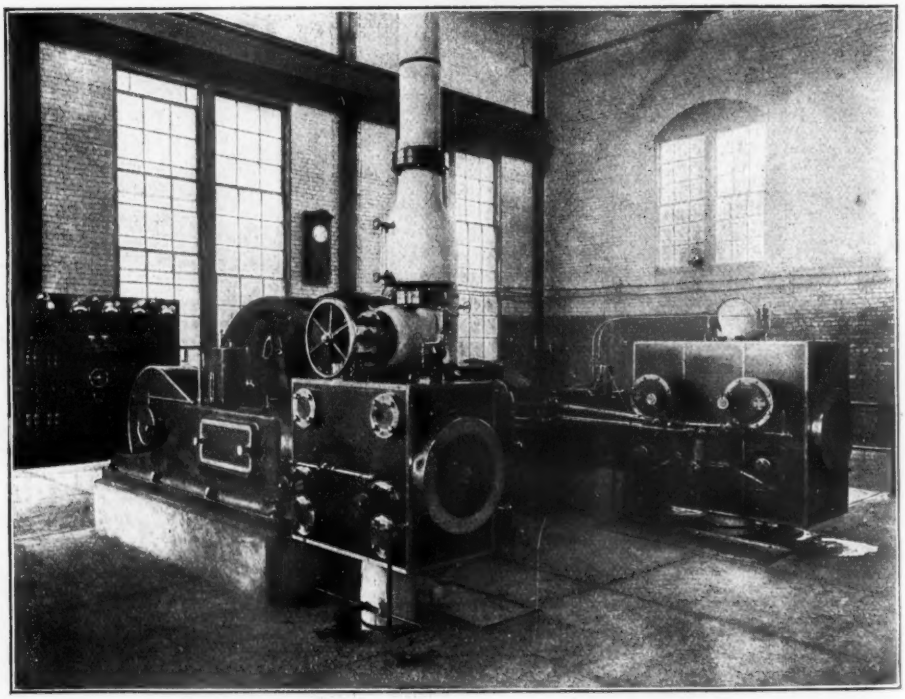

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Direct Connected to Generator, in Dean Electric Co. Plant, Elyria, Ohio.

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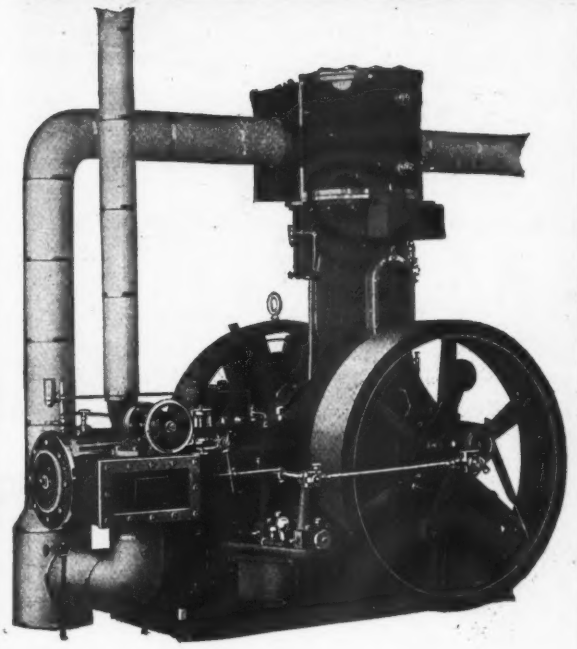

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is a notable feature of the new American-Ball Angle Compound. We place no reliance upon "splash" lubrication. A direct acting pump attached to the high pressure valve rock shaft forces a generous stream of oil through a system of direct pipes with sight feeds to every bearing point, flooding the surfaces and reducing friction to its "irreducible" minimum.

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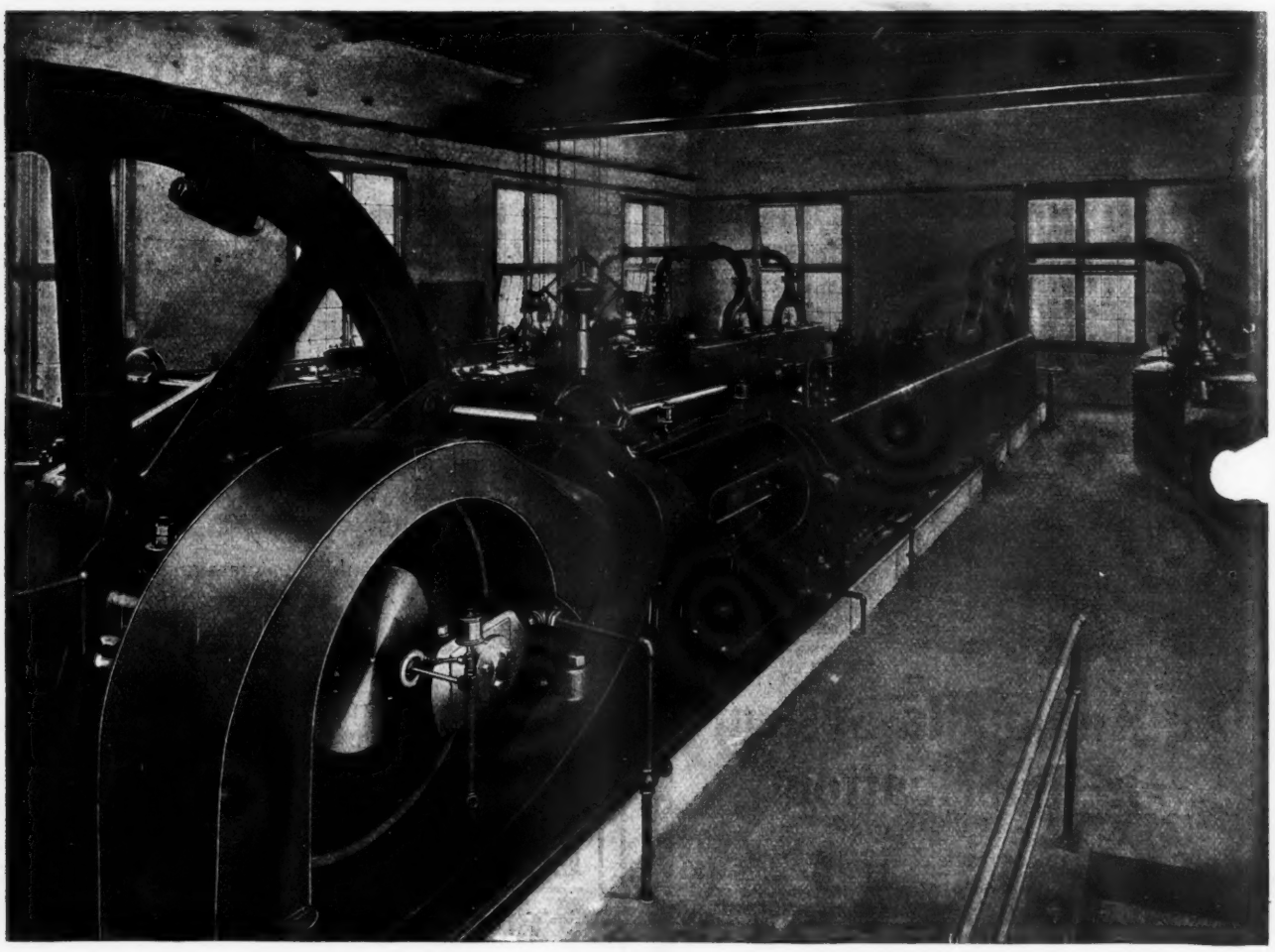
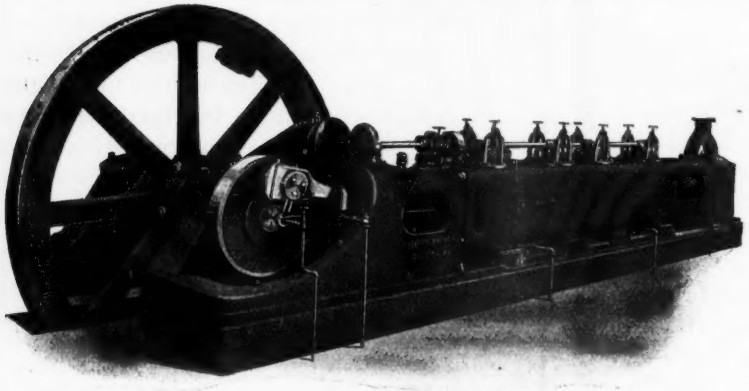
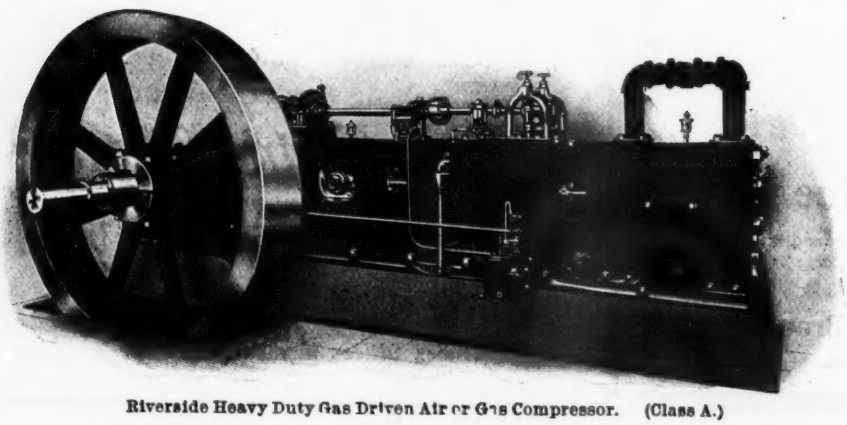


Riverside Heavy Duty Double Acting Twin Tandem (Class "G") Gas Engine. Direct Connected To Two Stage Natural Gas Pump.



Riverside Heavy Duty Gas Driven Air or Gas Compressor. (Class F.)



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